W. H. Hodding Esqr.
~~with~~ the best regards of his
old Friend
The Author.

THE ANATOMY OF THE HUMAN EYE.

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By JOHN DALRYMPLE,

ASSISTANT-SURGEON TO THE LONDON OPHTHALMIC INFIRMARY.

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TO

J. R. FARRE, M.D.

PHYSICIAN,

AND TO

FREDERICK TYRRELL AND JOHN SCOTT, ESQRS.

SURGEONS,

TO THE

LONDON OPHTHALMIC INFIRMARY,

THIS WORK

ON THE

ANATOMY OF THE HUMAN EYE,

OVER THE MANIFOLD DISORDERS OF WHICH THEY EXHIBIT SO MANY PROOFS OF CONSUMMATE MASTERY AND SKILL,

Is Dedicated by

Their sincere Friend,

JOHN DALRYMPLE.

PREFACE.

In the "Apology for British Anatomy," delivered by Dr. Farre in the year 1827, a plan for promoting the advancement of minute and morbid anatomy was submitted to the profession, and partially acted upon. During this period, I delivered to the pupils of the London Ophthalmic Infirmary a course of lectures upon the anatomy of the human eye, accompanied by a series of dissections laboriously and minutely followed out. For the purpose of these lectures many authors were of course consulted, and the knowledge contained in their respective works selected and condensed. In my search for authorities, I found no work in the English language, especially dedicated to the anatomy of the organ of vision, excepting perhaps Dr. Porterfield's treatise on the eye: whilst of the continental writers, the admirable work of the illustrious Zinn stood prominently forward as a solid text-book to this interesting subject.

To the honor, however, of our native anatomists, very numerous monographs on separate and particular structures of that organ are to be found, either

published in a distinct form, or scattered through our scientific journals. But written at very different periods, and almost wholly without system or arrangement, it is difficult, at least for students, to avail themselves of the valuable treasures they contain.

Under these circumstances, I have been induced to combine in a monographic form the many discoveries and improvements that have of late years enriched this department of anatomical science. During the execution of this design, the highly valuable labours of Mr. Lawrence, and of Mr. Mackenzie of Glasgow, in the pathology of the human eye, have been hailed with brilliant and merited applause. An attentive perusal of these masterly performances has strengthend in no slight degree my preconceived impression, that a work strictly dedicated to the anatomy of that organ, whose diseases the above-mentioned authors have so deeply examined, would not be unacceptable to the junior members of the profession; particularly as such a work will be necessarily more comprehensive, and in more minute detail, than the narrow limits of an introductory anatomical chapter in works, exclusively appropriated to its pathology and therapeutics, would allow.

When in the following pages the views of other

writers are cited, they are introduced always with a due regard to what I conceive to be their true meaning, and as often as possible in their own words; since it is of the highest importance in justice both to them and to myself, especially where we may chance to differ in our respective opinions, that they should be stated with the utmost accuracy and distinctness; and thus the charge of attempting to pervert, or torture their sense and expressions, will be avoided. This must form my apology for the frequent quotations which occur in the body of the work.

As to what may appertain more exclusively to myself in the description of any tissue or arrangement of structures, I deeply feel my responsibility; and am prepared to submit, with humility and respect, to the expressions of dissent with which such passages may be received. The consolation will however remain, that in such parts as may be deemed original, my sole aim has been the elucidation of scientific truth.

In conclusion, I beg to refer to a note placed at the end of the work, which has been introduced since the chapter upon the retina had passed through the press. As it will there appear that I have somewhat altered my opinion regarding the very interesting structure to which it relates, I shall feel greatly

flattered if those zealous anatomists, who have the opportunity of investigating such subjects, be induced to pursue a point so complicated with the conflicting opinions of past and present times as the real nature of the foramen of Soëmmering.

8, *New Broad Street;*
March, 1834.

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ANATOMY OF THE HUMAN EYE.

GENERAL OBSERVATIONS, ON THE ANATOMY OF THE ORGAN OF SIGHT.

The Eye is universally esteemed to be at once the most perfect, and the most beautiful of all the organs of the human body. For the convenience of particular and anatomical description, it may be divided into two parts.

First, the bulb of the eye.

Secondly, its appendages and defences.

The bulb or globe of the eye, contains within itself all those structures, which tend to modify the luminous rays proceeding from all objects, according to the known laws of optical science; together with a nervous provision for receiving and transmitting to the brain, or true percipient organ, the impression communicated by the rays of light.

The appendages, include the parts that are required for maintaining the growth and nourishment of the globe, with its moving powers and defences.

We may, without impropriety, liken the eye to the optical instrument known by the name of Camera Obscura; inasmuch as we find an outward case, a black lining, and a lens, with a provision for receiving the picture transmitted by the refracting media of its mechanism. Beyond this point, it is not permis-

sible to extend the analogy: the human eye being esteemed, on all hands, the most beautiful and perfect organ in the animal economy.

As in the description, which we shall subsequently have to present, of this marvellous machine, many structures will necessarily be mentioned, with the uses and even names of which the reader is presumed to be previously unacquainted, it will not be impertinent to prefix an abstract of the situation, relations, and arrangement of the several parts, constituting that curious whole, which we have ventured to compare to an optical instrument made by the hand of man.

The Globe of the Eye.

The eyes are two in number: they are situated towards the inner and anterior part of two bony cavities, called orbits, being separated from each other by the nose, and nasal fossæ, and lodged in a bed of fat, which, according to its greater or less development, determines the different degrees of prominence observable in the eyes of different individuals. They are usually of the same size in persons of the same sex; but are somewhat larger in the male than in the female. Their motions are performed by means of various muscles, and their vitality is supplied by an intricate arrangement of blood-vessels and of nerves; and they are wonderfully defended where the bony protection of the orbits is deficient, by a moveable integumental apparatus, called palpebræ or lids. These lids are elaborately composed of skin and muscle, of fibro-

cartilage, and glands, and hairs. The lachrymal appendages may be classed among the defences of the eye.

In shape, the globe of the eye is a slightly elongated spheroid, for if looked at in profile, it will be seen that the antero-posterior diameter exceeds the measure taken in any other direction: a transverse perpendicular section of the globe, taken at any part, will invariably exhibit a perfect circle; while a transverse plane, dividing it into an upper and lower, or a vertical section that cuts it into two lateral portions, will demonstrate an imperfect oval, of which the narrower extremity will be directed anteriorly.

The globe of the eye, in a living state, is equally resistent at every point, possessing a considerable degree of firmness under the pressure of the finger, scarcely allowing any impression to be made upon it. A few hours, however, after death, this resistent property begins to fade: the organ collapses, and loses its spheroidal form, owing to the transudation of its contained fluids, and the little elasticity of its membranous tunics. Posteriorly, the globe is connected with the brain through the medium of the optic nerve, which pierces the external case in this direction. Anteriorly, it is in contact with the lids, when the eye is closed; or simply, in relation to them by a common membrane, when it is uncovered.

The texture of the globe, is composed of three investments, or tunics, as they have been named, although the structure and functions of some of

them may be cited with great force against the use of so indeterminate, so inexact a phrase; yet custom, or the long habit and the familiarity of the term, may sanction, perhaps, its adoption for the convenience of description. These investments may be severally subdivided into different parts, of which the following table will serve to exhibit the arrangement, and the names.

TABLE OF THE TUNICS OF THE EYE.

Order.	*Situation.*	*Structure.*	*Name.*
1st External case.	Posterior and Opaque.	Fibrous.	Sclerotic and sheath of Optic nerve.
	Anterior and Transparent.	Laminated.	Cornea.
2nd Intermediate.	Posterior.	Vascular.	Choroid.
	Middle.	Cellular and Vascular.	Ciliary circle, Ciliary body, Ciliary processes.
	Anterior.	Muscular.	Iris.
3rd or Internal.	External.	Serous.	Membrana Jacobi common to the Choroid & Retina.
	Middle.	Nervous.	Retina.
	Internal.	Vascular.	Tunica Vasculosa Retinæ.

Within these tunics or investments, there is contained another and a distinct class of structures, usually denominated "the humours of the eye." In fact, they are "dioptric or refracting media," and

should in all propriety be so entitled. These are three in number, and they distend equally, and on every side the globe of the eye; on the due balance existing between the secretion and absorption of two at least of these organs, depends the firm and healthy resistance of the eyeball.

Two of the refracting media are fluid, each possessing its proper and peculiar degree of density; they are generally and wholly devoid of colour, and contained in delicately transparent capsules.

The third medium, is a semi-solid body; like the others it is perfectly transparent, and like them also it is invested in an exquisitely beautiful capsule. The whole may be arranged in the following order:—

TABLE OF THE HUMOURS OF THE EYE, OR REFRACTING MEDIA OF THE EYE.

Order.	*Situation.*	*Character.*	*Name.*
Vitreous body	Posterior.	Fluid and Membranous.	Vitreous fluid and Hyaloid membrane.
Lenticular body.	Intermediate.	Semi-solid and Membranous.	Crystalline lens and Lenticular capsule.
Aqueous body.	Anterior.	Fluid and Membranous.	Aqueous fluid and Aqueous membrane.

Presupposing in the reader a general knowledge of the laws of physical optics, it may not be amiss prior to the particular description of each part, to construct the instrument from the materials given

in the preceding tables; taking a superficial view, as we proceed, of the uses of the different tissues of which it is composed. Thus, then, the external globular case is made up of two membranes, which are flexible, but firm and unyielding, destined to support and defend both the fluids, and delicate membranes contained within them. These tunics differ from each other in this grand point, that the smaller of the two fills up the fore part of the *sclerotic*, which is a truncated sphere, and being transparent, serves as a window for the admission of the rays of light: this tunic is called the *cornea.* The posterior or sclerotic, is firm, dense, opaque, and pierced behind by the optic nerve, which forms a communication between the interior of the eye and the brain.

Within the external case, is a more delicate membrane, named the *choroid*, which is concentric to the sclerotic, and remarkable for the black pigment that lines its internal surface, and absorbs the rays of light, after their impression has been formed upon the retina, or nervous layer; in this way preventing that confusion and dazzling, that would otherwise result from reflection from its surface. Next to this coat or choroid, but separated from it by a fine serous membrane named *tunica Jacobi*, is the *retina*, or expansion of the optic nerve; not in itself a single membrane, but composed of more than one layer. This is the surface that receives the impression made by the impinging rays, and transmits it to the sensorium, by means of the optic nerve, which forms a solid cord, and goes off from its posterior portion. In order to modify the intensity of the light

necessary to distinct vision, and to regulate the quantity admitted, the interior of the eye is furnished with what is called in optics a diaphragm, and in anatomy the iris,—one of the most beautiful portions of this living mechanism. This moveable membrane not only regulates the admission of the rays of light, but also corrects "the aberration of sphericity."

The dioptric media, are three in number, properly so called. The *aqueous* of slight refracting power, occupies the anterior portion of the interior of the globe, and is found in two unequal spaces, called the chambers of the eye. Although these two chambers communicate most freely, yet as they are somewhat divided by means of the iris, they are anatomically distinguished into anterior and posterior. The second refractive body is the *crystalline lens*, which forms the posterior boundary of the posterior aqueous chamber, and is the most powerful of the optical agents, as from its peculiar shape it causes the luminous divergent cones to bring to a point, or focus, on the sensible nervous structure before spoken of. As, however, their rays would be decomposed by their passage through the lens only, and consequently a coloured image be formed upon the retina, a third body is introduced in the *vitreous*; which, partly spherical, admits into a concavity on its anterior surface, the crystalline lens: a combination, from the different refracting powers and shape of each, correcting the dispersion, and completing the organ, as a most perfect specimen of an achromatic optical instrument.

Not intending to enter into any systematic remarks upon the science of vision, which rather belong to professed works upon physiology and optics, I have merely introduced these observations as a slight outline of the eye, intending them as an introduction to the more minute anatomy of each structure, which will follow in the order and arrangement laid down in the preceding tables, at pages 4, 5.

The External Tunic of the Globe.

The Sclerotic—derives its name from the Greek word σκλὴρος, expressive of the hardness and toughness of its structure. By the older writers, it was also termed κερατοειδὴς; and by others, "cornea." Those, however, who adopted the latter denomination, established the distinction of opaque and transparent cornea. The former term being applied to the posterior investment, which is now universally designated sclerotic; the latter, or anterior portion serving as the window of the eye, retains simply the name of cornea.

The sclerotic occupies rather more than four-fifths of the external case; in shape, a considerable segment of a sphere, truncated at its anterior part, and filled up by the transparent cornea, by its intimate union with which, the exterior investment of the eye is completed. Posteriorly, the sclerotic is pierced by the optic nerve. The sphere of which this membrane forms a segment, has a diameter of between nine and ten lines. The opening which it presents in front, measures about six lines. In its

texture, it is dense and unyielding, coriaceous in appearance, and nearly resembling a piece of white-leather; it possesses also somewhat of a metallic lustre on its exterior surface.

The sclerotic is made up of a number of fibres, elaborately interlaced without any determinate arrangement, entirely precluding a natural division into two distinct layers, as described by some of the older anatomists. An uncertain line of separation may be observed in the sclerotic of some of the lower animals; but if we attempt this in the human subject, the most delicate manipulation fails in demonstrating any but an arbitrary division, producing manifest laceration of the intertwisted fibres. The thickness of this structure varies at different parts, but with only slight exceptions, gradually increasing as we proceed backwards, towards the entrance of the optic nerve, where the sclerotic seems to have arrived at its utmost degree of thickness. If we except the extreme edge, where it joins the cornea, we shall find the thinnest point to be immediately posterior to the insertions of the muscles of the eye. In this idea, Petit and Zinn agree, in opposition to the opinion of Morgagni, who stated that the sclerotic was increased by the insertions of the straight muscles. The measures of the thickness of this tunic, may be taken at about a line and a half at the posterior part; immediately behind the insertion of the straight muscles, about half a line; and at its junction with the cornea, it presents a fine sharp edge, where its tenuity is scarcely appreciable.

The two surfaces of the sclerotic have very different appearances; the external is white, and somewhat irregular by the insertion of various muscles, and by the entries of numerous blood-vessels and nerves, bringing with them small cellular sheaths, that leave them, as they penetrate the sclerotic, to be lost on its external surface. The membranous sheaths, formed of condensed cellular tissue, are more distinct upon the muscles, following them to their insertions, and especially conspicuous upon the tendon of the superior oblique. From this assemblage of cellular structure, there results a general investment of the globe, almost in the form of a capsule, which separates it from the cushion of fat in which it is embedded. Four small indentations are seen at the posterior part of the anterior third of the globe, indicating the insertion of the four straight muscles; and two others, less distinctly marked, at the outer side of the middle third, behind the centre of motion, demonstrating the spot where the two oblique muscles form their attachments. Posteriorly, and immediately round the entrance of the optic nerve, may be seen numerous foramina, by which the ciliary nerves and arteries enter; a little before these are placed the openings by which the veins from the interior emerge; some few similar perforations are seen at a short distance from the junction of the cornea, performing a similar office, namely, the entry and exit of blood-vessels.

The internal surface presents a very different aspect; taken generally, it is smooth, or slightly flocculent from the adhesion of a fine cellular tissue,

which for obvious reasons never contains any fat. This is the medium of connexion between the sclerotic and choroid coat, which it invests, and to which it corresponds throughout. From this circumstance, instead of finding the white and somewhat glistening appearance of the exterior, it is coloured slightly brown, more or less darkly so according to the individual; and constantly deeper towards the posterior part, where its adhesion to the choroid is more close: this is the result of the transudation of the black pigment secreted by the latter membrane, probably existing during life, and not as some have affirmed, solely a post-mortem appearance. If an eye has been minutely injected, and the choroid removed, we may observe numerous red points at the posterior part of the inner surface of the sclerotic, surrounding as a zone the entrance of the optic nerve. This appearance is to be attributed to the division of the short ciliary arteries, which are very numerous at this point. Anteriorly, are the openings of the long arteries of the same name; and a little behind the centre of this coat, are four oblique openings of a larger size, through which the venous trunks pass in order to arrive at the exterior of the globe. These appearances correspond to the perforations mentioned as seen on the external surface. If a section of the sclerotic be made, so as to divide it into two lateral portions, we may observe small canals, that traverse from behind forwards, obliquely through the thickness of the membrane; through these pass the nerves and arteries before alluded to.

The circular edge of the sclerotic, where it joins

the cornea, and which, we shall afterwards find, corresponds to the ciliary circle, is marked on this surface, by a shallow groove, coloured on its posterior edge, somewhat browner than the rest of the membrane; this seems owing to its firm adhesion to the choroid at this precise spot.

At the posterior part of the sclerotic, situated at the inner side of its antero-posterior axis, is the hollow by which the optic nerve forms its communication with the interior of the eye. The optic nerve having arrived in the orbit, by the optic foramen, in an oblique direction somewhat outwards, is invested by a sheath continuous with the dura mater, until it reaches the sclerotic, when it seems to throw off this investment, and enter, as it were, a cul de sac in the sclerotic itself. At this point, the nerve seems much contracted, as if begirt with a cord; and instead of directly piercing the external case, in order to gain the interior of the globe, it is stopped by a thin continuation of the sclerotic, perforated with numerous holes, through which the various fibrils of the nerve pass, in order to expand into the medullary structure called retina: from these perforations, this part has been denominated the "lamina cribrosa," or sieve-like plate of the sclerotic. The existence of this plate may be made manifest, by firmly pressing forwards the optic nerve from without: by thus proceeding, the medullary matter of the nerve will be observed making its escape at minute points, upon the internal surface of this plate. In the centre of these points, there is a small foramen left, as it were, vacant; or in place of brain-

like matter, a minute speck of blood will be perceived. This is the aperture which gives passage to the "central artery of the retina."

I am aware that some recent anatomists have denied the existence of the cribriform plate altogether, and account for the appearances above described, as consequent upon pressure, in a different manner. The optic nerve, is made up of bundles of medullary matter, enclosed in minute sheaths of membrane; if therefore, we press the nerve, its brain-like substance will be forced through the truncated ends of these envelopments, which here leave the bundles to allow of their expansion into a general membrane,—the retina. The "*lamina cribrosa*," has however been so well described by many and such excellent authorities, and indeed is so easily demonstrable by dissection, that I am much more inclined to admit than to deny its existence.

The sheath of the optic nerve being continuous with the dura mater, and subsequently becoming connected with the fibrous tunic of the eye, has been the ground of various opinions concerning the origin of the sclerotic. Many celebrated anatomists of old time, have upheld the favourite hypothesis of the derivation of the different tunics of the eyeball from the various meninges of the brain. Thus, Galen and his followers asserted, that the sclerotic was derived from the dura mater; the choroid, from the pia mater. Zinn, so accurate in most instances, falls into the common error of supposing this intimate connexion of the cerebral and ocular investments. Not wishing, however, to tread in the footsteps of

Galen, he has substituted a theory of his own; affirming, that the dura mater, which is continued on the sheath of the optic nerve, expands to form the *outer layer* of the sclerotic; while the inner, he argues, is formed by the pia mater descending with the same nerve, enveloping its various fibrils, and leaving them at their passage through the lamina cribrosa.

The ingenuity of certain authors, has been severely exercised in endeavouring to establish this derivation of the tunics of the eye, from the brain and its membranes. Thus, Dr. Read, in his Manual of Anatomy of Man (1650, 4th edition), speaking of the *first pair*, or optic nerves, says, "These nerves cannot be divided into many twists as other nerves are, but frame the tunicles of the eye: for the cornea doth proceed from the thick membrane (dura mater); the uvea, from the thin membrane (pia mater); the retina, from the marrowy substance." A modern writer, however, carries his analogy further than any preceding anatomists. Agreeing with Galen, that the dura mater is intimately connected, through the medium of the sheath of the nerve, with the sclerotic, he deduces the internal layer (which he says, is more easily detached at the early epochs of life than in the adult), from the arachnoid. "Ce feuillet," says Meckel, "tres mince, est un prolongement, non de la pie mère, comme on le suppose depuis Zinn, mais de l'enveloppe, que l'arachnoïde fournit au nerf optique, et avec laquelle il se continue d'une manière manifeste." (Manuel d'Anatomie, Tom III. p. 222.) Now, did this membrane

exist, being of the serous class, it would follow, in order to correspond with the known laws of these tissues, that, after it had lined the sclerotic coat, it would be reflected upon the tunic next to it, and become a double reflected membrane, and a closed sac. This state of parts, Meckel does not only not attempt to prove, but on the contrary, he expressly states, that this serous lining of the sclerotic coat is intimately united to the choroid by the intervention of a loose cellular tissue. The sheath of the optic nerve, may be evidently traced to a continuation of the dura mater. It, however, loses somewhat of its firmness, as it enters the orbit; and though it obviously continues to possess a fibrous character, it becomes much intermixed with condensed cellular tissue. At the posterior part of the globe, this sheath is firmly and intimately connected with the sclerotic; not, as it were, forming and expanding, in its own proper structure, into the external case of the eye, but rather blended and confounded with a tissue, similar in general character, though differing from it in being infinitely more dense and inelastic, composed of fibres less determinately arranged, and wanting much of the tendinous glistening appearance of the dura mater. From all these circumstances, I rather incline to the opinion of Albinus and of his disciples, together with Winslow and others, that the sclerotic is essentially peculiar to the eye; belonging to the general class of fibrous membranes, and intimately blended with the sheath of the optic nerve.

The anterior third part of the external surface of

the sclerotic, comprises that portion of it, which is known in some anatomical works, by the name of "tunica albuginea." There is not, however, the faintest shade of reason why this should be described as a separate membrane, its remarkably white and glistening appearance being attributable to the following circumstance:—The four straight muscles are inserted around the sclerotic, at the commencement of its anterior third portion, by fine ribbon-like tendons, which, closely adherent at this point, expand somewhat anteriorly towards the junction of the cornea; not, however, uniting into a common aponeurosis, as Galen, Ruysch, and Winslow believed. This partial expansion with their fine cellular investments, gives to the sclerotic a white and more brilliant aspect, at this point, than elsewhere; and shining through a thin transparent membrane, common to the fore part of the globe and the eyelids, named conjunctiva, produces that glistening and almost irridescent surface, known in common language by the phrase, "white of the eye."

The existence of a separate tunic (Tunica albuginea or innominata of Columbus), though supported by the authority of the most eminent of the older writers, was doubted and denied by Stenon, Valsalva, the disciples of Albinus, and by Zinn.

At the front of the sclerotic a union takes place, as has been before observed, with another structure called cornea. The junction between these two is so intimate, that the most skilful knifesman is unable to detach the one from the other, without disturbing the integrity of each.

Some anatomical writers observe, that by means of long continued maceration, the cornea will separate itself from the sclerotic, and fall out, as a watch-glass from its verge. In this experiment, though I have often tried it, I have never been successful: but in order to expose the actual mode and form of junction, differing as it does in different subjects, a perfectly recent eye should be divided by a clean vertical section, and by this simple process, by the difference of structure displayed, the transparency of the one and the opacity of the other, it marks not only the precise point of junction, but the real manner of their union. The anterior edge of the sclerotic, is prolonged over the circumference of the cornea, by the peculiar adjustment of each; for as the external surface of the former coat is prolonged beyond the internal, it leaves an oblique edge, sloping backwards and inwards, bevelled off, as it were, to meet the cornea cut in a contrary direction, by which means the cornea is enclosed, and retained somewhat like to the fitting in of a watch-glass. From the edges thus meeting, small fibres pass from the two structures intimately interlacing, and securing their firm adhesion. This junction is strengthened by a membrane attached both to the sclerotic and cornea, as will be hereafter described in its separate place. As, however, the union between the two portions of the external case will be again adverted to, the varieties that occur in the precise mode of junction, will be deferred until after a special description of the cornea has been given; remarking however in this place, that the mode of

union above detailed, is by far the most frequent of the several varieties mentioned by different writers on this subject.

Organization of the Sclerotic.

The vessels, that supply blood to the exterior of the sclerotic, are derived mainly from the long and short ciliary arteries, the principal destination of which being for the internal structures, we find them transmitted by the oblique canals before spoken of. Some minute branches are, however, given off in their passage, for the supply of this coat. Anteriorly, they anastomose with twigs of the vessels that ramify on the common membrane, the conjunctiva. Posteriorly, with branches of the muscular arteries. The return of blood takes place by corresponding venous trunks. Ruysch, in his Theasaurus, gives a plate of these vessels, drawn from one of his splendid injections. The student may often, however, have it in his power to observe the number, minuteness, and intricate interlacement of these vessels in that injection, far surpassing all artificial imitations,—an *inflamed eye*.

The sclerotic receives but few nerves, although it gives transmission to so many. Some minute branches are, however, undoubtedly given off by the posterior ciliary, in their passage to the choroid. The anatomist is seldom fortunate enough to detect them without the aid of powerful magnifiers, and the most delicate manipulation.

Nothing will here be said of the existence, far less

of the course of lymphatic vessels, as that very obscure point will be examined in another portion of this work.

The sclerotic coat has relation, anteriorly, to the cornea and conjunctival tunic; posteriorly, it reposes upon a cushion of fat; indirectly, it is connected with the brain by means of the optic nerve; it is surrounded, and moved by six muscles; and it is nourished by, and gives transmission to numerous blood-vessels and nerves.

Cornea.

The *cornea,* has already been mentioned as that tunic which completes the sphere of the globe of the eye, before incomplete, owing to the sudden truncation of the sclerotic. It is *the window of the eye*, and serves to admit the rays of light, which undergo the various refractions, according to the density of the different transparent media, in such a manner as to form a picture of the external objects upon the nervous expansion of the retina.

The cornea is perfectly transparent, and polished, convex before, and forms the smaller segment of a smaller sphere than the sclerotic; so that instead of the ball of the eye being uniformly spherical, the cornea projects more forwards, or in other words, it is more prominent than it would be, if the sclerotic were completed after its own proportions. This is so regularly the case, and the commencement of the new segment so accurately defined, that were other reasons wanting, this alone would authorize the

inference, that the cornea is a separate and distinct formation, not, as the older anatomists believed, a continuation of the sclerotic.

Like the sclerotic, the cornea is a fibrous membrane, and the only point of affinity between them is, that they both belong to the same general class of elementary tissues.

In the cornea, there is no interlacement of fibres so intimate as to be difficult, if not incapable of separation: on the contrary, the cornea is composed of separate and distinct lamellæ, regularly applied one over the other, concentric, beautifully transparent, and connected with each other by a delicate cellular tissue. These layers are separable from each other, and, after a little maceration, may be exhibited at once distinct and pellucid. The reticular tissue uniting them, contains in its cells a clear fluid, which passes readily from one cell to the other, permeating the layers of the cornea with great facility. This fluid performs a most important office in maintaining the perfect transparency of the cornea, by an equable distension of its cells; which may be proved by the following experiment:—If, in a fresh eye, while the cornea is yet perfectly transparent, we make pressure by the nail on one point, the fluid beneath the finger passes, or is forced into other cells, and the spot so pressed upon becomes opaque; it returns to its former pellucid state on the removal of the force applied. The transudation of the fluid, also, after death, renders these lamellæ opaque, and causes them to slide over each other, when pressed beneath the finger. Steno seems to have been the

first in order of time, that observed this transudation of the corneal fluid, as appears by a note of Wrisberg, in his edition of Zinn's "Anatomy of the Human Eye." From the circumstance of this fine cellular net-work being always full of fluid ("Cujus areolæ aquâ pellucidissimâ semper sunt ebriæ," Zinn), anatomical writers have denominated it, the "substantia spongiosa corneæ." To it also the tunic under notice owes a considerable portion of its substance.

The cornea is always thicker than the anterior part of the sclerotic, where it sometimes exceeds it by nearly half a line; this is so evident in the fœtus (in which it is less transparent, and of a reddish colour), that at no part is the sclerotic so thick; and this difference between the coats, has, at this epoch of life, the effect of diminishing the space between the cornea and iris, by nearly one third of its capacity.

As the concavity of the cornea nearly equals the convexity, it follows of course, that this tunic is almost equally thick throughout its whole extent,* excepting of course at its immediate circumference, which is cut in a sloping direction at its anterior surface, so that the sclerotic may overlap it, as was mentioned when speaking of the junction of those parts. It was then remarked, that such was the most ordinary form of union; but as there do exist two other modes of junction, though certainly more

* We have, however, the high authority of Sir E. Home, and Mr. Ramsden, on this subject, who made some very minute and accurate experiments; wherein the result stated was, that the cornea is thickest, as well as most elastic, in its very centre.

rare, we may, with all propriety, speak of them in this place.

The second is, where both surfaces of the cornea slope gradually to a sharp edge, which is received into a furrow hollowed in the thickness of the sclerotic, and then it may be fairly said to be set as a watch-glass in its circular verge. The third and most unusual variety, is, where the cornea overlaps the sclerotic, so that the internal edge of the cornea is less prolonged than the external, in a direction precisely opposite to that which occurs in the first or most common mode of union.

By aid of some very ingenious mechanism, contrived by the celebrated Mr. Ramsden, Sir E. Home instituted a series of experiments, to ascertain the changes of the figure of the eye in adapting the organ to the vision of near and distant objects: and he observed that the convexity of the cornea underwent various modifications, when the eye rested on objects placed at different distances. In order to account for these changes, he revived the opinion of Morgagni and Briggs, that the tendons of the straight muscles were rather inserted into, or fairly expanded over the whole surface of the cornea. Sir E. Home has also given a plate of a preparation, in which the anterior layer of this tunic has been skilfully stripped off, continuous with the expanded tendons of these muscles. This question has been amply discussed by Zinn, to whose opinion I incline, when speaking of the theory of Briggs: "Cornea nihil aliud esse videbatur nisi fibræ motrices e sclerotica transeuntes," he says, "Sed hanc opìnionem

non necesse erit refutare, qui superius jam docuimus, tendines neque in continuam tunicam expandi, neque ad corneam pertingere." (Zinn, p. 16.)

While treating of the so named tunica albuginea, reference was made to a membrane, common to the globe of the eye and eyelids, called conjunctiva, that passed over the expanded insertions of the straight muscles; and although it will be more convenient to describe this tunic elsewhere, we must not omit to state our belief, that it does not terminate by being firmly attached to the circumference of the cornea, at its union with the sclerotic, but that it is continued over the cornea, and affords to it an anterior investment. The opinions on this subject are various, such a disposition being denied by many most respectable authorities: but we shall recur to this point more at large when speaking of "the defences of the eye."

The figure of the cornea is not perfectly circular; and by reference to Meckel, we find that he describes the superior edge to form the segment of a perfect sphere, while its external side is elliptical. Morgagni states the cornea to be elliptical generally, and compares it to the eye of an ox. I rather hold, however, to the opinion of Haller; who, in his first "Lines of Physiology," states it to be circular towards the nose, and oval at the side corresponding to the temple: this I believe to be the natural and most frequent arrangement of the parts.

Immediately anterior to the line of junction between the sclerotic and cornea, on the posterior aspect of the latter tunic, a shallow groove runs

around its edge, marking the place where the iris meets the ciliary circle, and is attached. From this point forwards, by a delicate manipulation, a membrane may be separated from the posterior surface of the cornea, rarely entire, but in small shreds: this dissection may be effected with greater facility, than the separation of the lamellæ of the cornea, and may be done so much the more readily if the eye has been macerated for a short time, or submitted to the action of boiling water. This membrane has been called the "membrana aquosa;" which term Meckel deems inappropriate, since according to his view, it does not assist in secreting the aqueous fluid. Whether it be proper to the cornea, or whether as a serous membrane it be reflected over the iris, we shall leave undiscussed, until we come to treat of the aqueous fluid, and the sources whence it is derived. The discovery of this membrane has been attributed to Sawrey, who published an account of it in a treatise, entitled, "A Newly discovered Membrane in the Human Eye." (London, 1807.)

Organization of the Cornea.

From whatever source the cornea receives its supply of blood, in the healthy state of the parts, the vessels admit no red particles; and by injection, we find a numerous net-work of arteries and veins, forming a zone beautifully painted upon the sclerotic, but stopping at once and abruptly at the circumference of the cornea. In disease, however, under peculiar forms of inflammation, red blood is freely

admitted into the before invisible vessels, so that the whole substance of the cornea will become highly injected. We must be careful, however, not to confound this appearance with certain states of inflammatory action, where the vascularity is confined to the membrane that covers the anterior surface of the eye. That the cornea is highly organized, and furnished with vessels of all kinds, is proved by the results of unhealthy action. The effusion of lymph into the interstitial texture of the cornea rendering this tunic opaque, proves the secreting or depositing power of its arteries; while, on the other hand, the rapid ulcerations occasionally occurring, no less clearly evince the existence either of absorbent vessels, or an equivalent power in the veins. Nerves cannot be traced to this tissue; but though it be not acutely sensible, yet as pain is felt under the circumstance of lesion, we cannot in our present state of anatomical knowledge altogether deny their presence.

Having thus by the addition of the cornea to the sclerotic, completed the description of the external case of the eye, the dimensions of the globe may, with propriety, be here mentioned. The transverse middle diameter of the eye, is about one inch in extent, whilst the section dividing it into an anterior and posterior segment, will be perfectly circular. The measures of a section, dividing the eye into two lateral, or into an upper and lower portion, equal each other; but exceed the former segments, by about two lines in length. So that, by the greater convexity of the cornea, the antero-posterior diameter

exceeds that which can be taken in any other direction.

The thickest part of the sclerotic is found around the entrance of the optic nerve, where it measures one line and a half; at its junction with the cornea, it measures half a line; and immediately behind the insertion of the straight muscles, its extent is somewhat less than this. The cornea is *nearly* equally thick throughout, and measures about three-fourths of a line. Petit describes this tunic as forming the arc of a sphere, having a diameter of about seven and a half lines.

The Choroid.

If we remove the sclerotic and cornea, we find the transparent media of the eye, excepting the aqueous fluid which escapes, still retained in their positions, by a dark investment, that forms the first of the internal membranes of the eye. This tunic has received the name of chorioid, or choroid, derived from the Greek words χοριον and ειδος, as it is supposed to resemble the membrane chorion, which envelopes the fœtus in utero. More anciently, it was named by the Greek writers, "ῥαγοειδὴς," from its supposed resemblance to a grape-stone; also the Latin term *uvea*, formerly was applied to the whole choroid, but is now restricted to the posterior surface of the iris.

This membrane is placed within the sclerotic, to which it corresponds, and adheres loosely at every part, extending from the entrance of the optic nerve,

to the junction of the sclerotic and cornea; terminating in the ciliary circle, which we shall, hereafter, have occasion more particularly to describe. At its internal surface, it presents no point of adhesion to the retina, which it surrounds, and to which it is concentric. The choroid is highly vascular; of a brown colour, and remarkable for a dark pigment, which it secretes.

Many and various have been the opinions given to the world at different periods, by the most eminent anatomical authors, relative to the origin of this tunic. The illustrious Morgagni conceived, that it might be clearly divided into two laminæ; the exterior of which he derives from the arachnoid, the interior from the pia mater of the brain, prolonged upon the optic nerve. Le Cat, a name of authority among the older writers, imagines, that the pia mater arriving with the optic nerve at the inner surface of the sclerotic, divides into two layers, one of which passes into the sclerotic, whilst the other forms the choroid membrane. The opinion held by Albinus, by Winslow, and by Zinn, appears to be more exact, and more consistent with fact and truth; namely, that the choroid is a membrane essentially peculiar to the eye. It is not, however, to be denied, that some slight affinity in structure to the dura and pia mater, may be observed in the sclerotic, and the membrane of which we are now treating.

All anatomists, from the time of Galen to the present day, have recognised the vascular formation of the choroid. It may be said to be composed of an infinite number of blood-vessels (arteries and

veins), united by a fine cellular tissue, and interwoven in the most beautiful arrangement: a disposition, indeed, so accurate, so wonderfully distinct, and so constant, that there are few structures of the human body surpassing this in beauty, or more calculated to excite the admiration of the observer. Morgagni has stated, that besides this peculiar distribution of vessels, some black fibres, separate from both arteries and veins, enter into the composition of the choroid. In this opinion, Maitrejean agrees; observing, that these fibres pass in a radiating direction, from the point where the optic nerve pierces towards the anterior part of the membrane. This idea, however, did not obtain the assent of equally respectable authorities of that day; and as it is universally rejected by the moderns, we are fairly entitled to deny the existence of such fibres.

If the sclerotic be carefully detached, leaving only the optic nerve at the posterior part, we see, besides the fine cellular tissue connecting the choroid with the sclerotic, and which is, by contact, stained of a dusky brown colour, a vast assemblage of nerves, veins, and arteries, which will be observed chiefly running from the back part of the eye forwards, until they merge in the ciliary circle. These are for the most part, the ciliary arteries and veins, with the long and short nerves of the same name. A description of these will be given in another place.

At the posterior part, the choroid may be separated into two layers; a division, however, purely artificial. The exterior is chiefly made up of the first interlacement of the short ciliary arteries, and

more anteriorly, of a remarkable arrangement of veins, whose beautiful disposition and ramifications are known by the name of "vasa vorticosa. When we turn to the concave surface of this membrane, and wash off the dark pigment, with which it is so plentifully lined, we observe it commencing around the entrance of the optic nerve by a salient ring, but so unadherent to it, as completely to annihilate the supposition of its deriving its origin from the pia mater of the nerve. As it passes forward to its termination in the ciliary circle, we find the commencement of some small black folds, or plicæ, that become continuous with similar folds on the ciliary body. These plicæ may have given rise to the idea of the existence of the radiating fibres in the composition of this tissue, which were thought by the ancients to be even muscular.

The inner surface is made up of an infinite number of arteries, so minutely divided, and anastomosing so frequently, as to form a complete vascular network. By a successful injection, this interlacement gives to the surface an almost villous appearance; and if a portion of it, well filled with red size injection, be placed in a little fluid under a strong magnifying power, a number of minute points may be seen to float in the water, giving the whole the aspect of a piece of scarlet velvet. It was from one of these splendid injections, for which Ruysch was so celebrated, that he gave his remarkable description of what he termed a separate layer of the choroid; subsequently called by his son "Tunica Ruyschiana." The following lines, literally trans-

lated from that excellent writer, Zinn, are admirably descriptive of the intricate ramifications of the choroidal vessels on their surface. "When a lens is used," he says, "which much magnifies the object, we meet with one of the most elegant structures in the human body, which cannot fail to strike with pleasure any one, who is not wholly incurious in matters of this sort. There appear innumerable straight arteries, larger or smaller, repeatedly ramifying under the most acute angles, parallel to, and applied in the densest series against, each other; enclosing, as it were, a thousand little islands (plurimas insulas). These arteries are spread out, on the internal surface, into a magnificent net-work of the most minute vessels, all nearly of the same size, formed into quadrangular, and rhomboidal areas, and closely resembling a huntsman's net; constituting a reticular texture, like the ultimate ramifications of the pulmonary vessels."

Having thus described the internal surface as almost wholly composed of a series of arteries, we pass to the equally curious external superficies, principally formed of veins. The primary branches of these veins, arising from the extreme ends of the arteries, soon arrange themselves into a peculiar order, and pass to the exterior of the choroid, directed for the most part from behind forwards, radiating from the periphery, and divided into four sets towards larger trunks situated between each set. The branches, as they proceed forwards, bend suddenly upon themselves with a peculiar curve, towards the main trunks, into which they open. Those near

the main canals, have a short and nearly straight course, making but a slight curve, previous to their discharging themselves into the large veins. The more remote ones, however, take a semi-circular course; they anastomose frequently with each other, and receive anteriorly the veins from the ciliary body and iris, then passing backwards on themselves, they unite with the set coming in an opposite direction, and form the commencement of the larger or proper ciliary veins. From their peculiar course, they have been termed the "*vasa vorticosa;*" and their successful injection, forms a beautiful and curious preparation. This singular arrangement has an arborescent appearance, often compared to weeping willows; the ciliary veins being analogous to the trunks, and the vasa vorticosa to the pendant, and as it were, weeping branches of these elegant trees. The great Haller was the first who pointed out the true nature of these vessels, anatomists prior to his time having considered them as arteries. It is not an unfrequent occurrence to find them fully injected after death with blood, where any obstruction to the return of blood by the jugular veins has existed, as in death by hanging, &c.

We have observed, that the choroid is of a deep brown colour, approaching to black: this hue pervades the whole texture of this tunic, and even stains the sclerotic by the transudation of the black pigment, which lines its concave surface. The "pigmentum nigrum," as it is termed, is not absolutely black, but of a dark brown or bistre colour, secreted from the whole of the internal surface of the choroid,

increasing both in quantity and intensity of colour towards the posterior part of this membrane; it is also met with on the ciliary body, on the ciliary processes, and at the back of the iris. If the choroid of a perfectly fresh eye be placed in clean water, and agitated in it, the pigment does not mix with the fluid, and render it turbid; nor will it stain the moistened finger, if it be only lightly drawn over its surface. We shall also see, that the retina, although apparently in contact with the choroid, remains unstained; while, on the contrary, the sclerotic, though opposed to the contrary surface of the membrane, is deeply tinged with this same matter. Again, if the eye be not quite fresh, or if the choroid be macerated for a day or two in clear water, the pigment will be found to peel off in little black membranous shreds, or flocculi; and with a camel's-hair pencil lightly used, we are enabled to detach nearly the whole mass. The subsequent maceration for a few days, in water frequently changed, reduces the choroid to nearly a white colour; proving, that its dusky hue is wholly dependant on this singular secretion. From these, and other facts, we shall endeavour to shew in another place, that the choroid is, at its internal or concave surface, invested by another membrane, which prevents the pigment painting the retina and its proper covering; and, why instead of mixing with the water, it may be made to peel off in flocculi in the recent or perfectly fresh eye. In different individuals, this secretion varies much in quantity, and depth of colour; and also in the same individual, in the different epochs of life. The intensity of

colour, seems also to agree with the differences of complexion exhibited by different races. Thus, in some persons it is of a light brown, and sparing in quantity; in others, darker and thicker. In children, and very young people, it is more abundant, and blacker than in the very old, in whom, indeed, we sometimes find it nearly altogether deficient. In the inhabitants of the frigid and torrid zones, it is generally darker and thicker than amongst those who dwell in the more temperate parts of the world. In the Albino, it is wholly wanting. In its nature, the pigment resembles a mucous secretion; and though darker than any other secretion of the human body, it bears some resemblance to the *rete mucosum* of the Negro. If mixed with water, and submitted to the microscope, we find it composed of an infinite number of small globules, whose chemical analysis gives a large proportion of carbon and iron. The following is a translation of the fanciful hypothesis concerning the nature and origin of the choroidal secretion, by a man well known to fame among the earlier authors, M. Le Cat. "The inside of glands, is the concourse of arterial and nervous extremities; in which concourse, the animal fluid is united to a volatile part of the blood, to enable it to discharge its functions. This union is made by means of the nervous and vasculary tufts. These tufts, in the eye, produce the down of the choroides. It is therefore highly probable, that the black liquid with which this down is embued, is nothing else than the sulphureous particles of the blood diffused in this texture by the tufts of the arteries, and loaded with

the volatile portion which is mixed with the animal fluid, conveyed by the nervous tufts. Or, if you please, this black liquid is the dregs, as it were, of the fluid that results from the mixture of the spirits with the volatile part of the blood. The animal fluid, in some degree, partakes of the nature of mercury. Now mercury, intimately united with sulphur, forms a black substance, an æthiops, as every body knows. In like manner, there is all possible room to imagine, that the eye presents to us traces of this so useful mixture; which we establish on no other basis, than that of the necessity there seems to be for it, in regard of almost all the functions, and principally of muscular motion." (Le Cat, on the Senses. London. 1750.) It is quite unnecessary to make any remarks on the absurdity of the foregoing passage, as it is merely introduced to shew how lamentably we must fail, when we attempt to explain the results of vital action, by laws founded either on chemical affinity, or mechanical science.

The inner surface of the choroid has, by some anatomists, been termed tapetum; and this term has been applied by Sir C. Bell, to that portion which has also been known as the tunica Ruyschiana; at least, so we must infer, if the latter name indicates the secreting and villous surface of the choroid, as, of course, it would be improper to designate the pigment itself by such a name. The word tapetum, as Sir C. Bell remarks in a note (Vol. III. p. 33. Anat. and Physiol.), was first applied by the French academicians to the bright reflecting surface which

presents so beautiul an appearance in several animals, especially in the rapacious and nocturnal quadrupeds. The phrase is, perhaps, happily adapted to explain the appearances seen in the choroid of many animals, but as no such structure exists in man, nor even any vestige bearing the slightest relation to the tapetum (for, in fact, in the human subject, this surface is rather absorbent of light than reflecting), I confess, that it appears to me not only to be highly inapplicable, but tending to confuse the student in his study of these parts. In those animals, where the tapetum is found, the pigment may also be observed, not universally spread over the inner surface of the choroid, but occupying a space of greater or less extent, and more abundant towards the anterior and external portions of this membrane. In some instances, we find the pigment covering the brilliant tapetum itself, although here it is very thin, and easily detached. I should not have thought it necessary to introduce these remarks, upon a structure which has no existence, I apprehend, in the human eye, were they not necessary for the explanation hereafter, of the membrane which covers the pigmentum nigrum, and consequently the concave surface of the choroid. This membrane, which equally exists in those animals that have, and *that have not* a tapetum, has been confounded with the layers of that brilliantly coloured tissue, as described in a work entitled, "A New Membrane in the Eye," by Mr. G. H. Fielding, of Hull.

The anterior termination of the choroid, or rather the place where that tunic becomes continuous with

the ciliary body, is marked by a scalloped line of deep brown pigment marking the point where the membrane, which lines the choroid and retains its secretion, passes off to be reflected upon the retina; the latter membrane being, as we shall see, terminated at the circumference of the canal of Petit, by small semi-circular indentations. The concavities of these segments, face anteriorly. Some German authors, amongst whom is Weber, recognise this line as the "ora serrata."

The Ciliary Circle.

The anterior termination of the choroid, forms a point of union between several of the membranes of the eye, bounded by a structure, which we shall call, after Maitrejean, the *ciliary circle.*

It is apparently a greyish coloured, strictly cellular texture, and possessing none of the characters of ligament, though frequently called by anatomists, the ciliary ligament. It is firmly adherent at the junction of the sclerotic and cornea, where it is received into that shallow groove, or sulcus, described as occurring at their immediate circumference. This circle forms the connecting medium between the choroid, which partly loses itself in its structure and the ciliary body, its processes, and the iris. In texture, it is soft and spongy, and infiltrated with fluid.

On the intimate organization of the ciliary circle, anatomists have wholly disagreed. Bichat has compared it to a collection of mucous glands; others, as St. Yves, have considered it to be composed of

tendinous fibres: while some moderns have believed it to be a plexus of nerves, or rather as a nervous ganglion. This latter conclusion, does not seem to be supported by physiological reasoning; neither can I admit it to possess any resemblance in its anatomical appearance. True it is, that many of the long ciliary nerves may be traced into its structure, and even through it, although not without difficulty and very imperfectly, until we perceive them emerging in order to be distributed upon the iris. Such a fact, however, is not sufficient to support the proposed theory, since in man the size of the ciliary circle bears no proportion between the nerves that enter and emerge; neither does there seem to be any reason, why so small a membrane as the iris, notwithstanding its great mobility, should be endowed with a nervous apparatus so remarkably, and out of all proportion, extensive. In man, we find the ciliary circle relatively more substantial, than in many animals possessing an iris of larger size, and of much more vivacious motion, as in the tiger.

The adhesion of the ciliary circle at the point of union between the sclerotic and cornea, is so firm, that, according to Zinn, air blown in through a small aperture in the posterior part of the sclerotic, will sooner separate this tunic from its union with the choroid, than pass the ciliary circle, and escape into the anterior chamber. Its chief use seems to serve as a connecting medium amongst the several textures, with which it is united, and to give a firm support to the iris, by which it is bounded anteriorly.

A correct knowledge of its relative situation, is

however, of considerable importance to the ophthalmic surgeon, as it forms a guide to him in some of the delicate operations for the cure of cataract. At its circumference, it strictly adheres to the point of union of the cornea and sclerotic membranes; behind, to the choroid, with the outer surface of which it is continuous; before, to the iris, which thus receives a firm point of attachment; and at its lesser circumference, or where it looks towards the pupil of the eye, it is continuous with the ciliary body and processes of the same name. Its breadth is about one line and a half.

This tissue does not seem, in itself, to be supplied with many vessels or nerves, although it gives passage to several in their course to the iris. The arteries, are the long and anterior ciliary arteries; the veins, those which return the blood from the iris and ciliary processes; and the nerves, that are destined principally to supply the iris, are derived from the ophthalmic ganglion, and nasal twig of the third division of the fifth pair of nerves.

Ciliary Body and Processes.

The ciliary processes, seem to have been known to the earliest anatomists, who, even before the time of Galen, described and named them on account of a supposed origin from and resemblance to the *cilia*, or eyelashes. Vesalius, and others of his æra (1540), considered them as boundaries which divided the eye into two equal halves (vide Pl. 2. fig. 1.), and placed them at so great a distance from the iris, as to en-

large the posterior chamber of the aqueous fluid to nearly five times its true capacity. Eustachius and Fallopius corrected this error, and rejecting the term Vesalian tunic, by which they were then known, described them as a means of connection between the choroid membrane and the crystalline lens.

Their nature was long unknown; by many, they were supposed to be vessels, destined to the support of the lens; by others, among whom is the celebrated Boerhaave, they were considered as muscles, whose fibres, rising from the anterior boundary of the choroid, were inserted into the circumference of the lens, and probably exerted some influence over the focal relations and powers of the eye. The opinion common to Winslow, Haller, and Heister, is that now commonly received; namely, that they are continuous with, and produced from the choroid: in fact, mere folds of this membrane.

Before we proceed to the description of these parts, it might be advantageous to determine the name by which, in the present observations, we shall uniformly distinguish this structure, in order to avoid the confusion and perplexity, that have arisen from the various denominations heretofore affixed to one and the same organ, by various writers. To this end we shall describe, under the name of *ciliary body*, the common origin by which it is continuous with the choroid, and attached to the ciliary circle; confining the term, ciliary processes, to those serrated plicæ, placed round the circumference of the crystalline lens.

Both these parts were called by Vesalius, the

ciliary tunic, and, after his death, received his name: other authors denominated them, the "ciliary ligaments," or "body." Haller named the free points, "ciliary ligaments:" Lieutard, the "ciliary rays:" Ruysch termed them, "tendons," maintaining their muscular origin, and believing them to be inserted, by many tendons, into the crystalline lens. We shall be content to take this structure as the ciliary body, terminating in those free points, which are now universally called the processes.

If an eye be cut transversely into two parts, about one-third of an inch behind the junction of the cornea and sclerotic, detaching the posterior part of this last tunic with the choroid and retina from the vitreous humour, we shall see, when the eye thus prepared is placed upon its corneal surface, shining through the vitreous humour and lens, a beautifully radiated circle, surrounding the circumference of the crystalline body; not dissimilar to the disk of a sunflower. This plicated ring represents the assemblage of the ciliary processes, attached by a common root to the ciliary circle.

In front of the processes, the iris is placed; these two parts are not, however, in contact, or adherent to each other; a circumstance which enables us to distinguish between them and the ciliary body, which latter is firmly connected to the iris, and in common with it, fixed at its greater circumference to the ciliary circle.

The relative position of these parts, may be thus described:—The posterior surface of the ciliary body, is continuous with the choroid; in contact

with the investing membrane of the "canal of Petit." The line which may be said to mark the distinction between the choroid and ciliary body, is that which we have referred to, as the "ora serrata." This serrated or scalloped edge, corresponds to the anterior termination of the retina, and is the point where, as we shall afterwards see, a fine membrane is reflected from the choroid on to the medullary expansion of the retina.

Anteriorly, the ciliary body is connected by cellular tissue with the iris; at its greatest circumference, it is firmly fixed by the circle of the same name. Its lesser circumference is terminated by a fringe of free points, or processes, separated from the iris by the water of the posterior chamber, but behind received into the minute sulci of the canal of Petit,—a curious structure immediately surrounding the crystalline lens. The ciliary body is slightly drawn up into plaits or folds, like the gathers of the wrist-band of a shirt: these plicæ commence at the extreme anterior verge of the choroid.

Both the ciliary body and processes are deeply stained with the pigment, which, here as well as upon the posterior surface of the iris, is secreted in great abundance.

Ciliary Processes.

The ciliary processes, which result from, and may be said to terminate, the ciliary body, vary from seventy to eighty-five in number. In shape, they are somewhat triangular, and of unequal length, each

alternate one being shorter than the other. Their apices, form the lesser circumference; their posterior edges, are received into the small radiating furrows surrounding the margin of the lens, formed in the membrane composing the anterior layer of the canal of Petit. In colour, they are of a dark grey, covered with pigment, though less thickly stained themselves than their interstices; since, if we raise the ciliary body from the vitreous humour, in an eye that is not quite fresh, we observe the furrows in Petit's canal, in which the processes were lodged, clear and transparent, while their interstices are deeply stained. In their general arrangement, they form a beautiful radiated ring, denominated by some authors, "corona ciliaris."

The ciliary body, is adherent to the iris anteriorly; and although it is difficult to separate them, without laceration, or disturbing the integrity of each, we must not, therefore, suffer ourselves to conclude that the intimate organization of the one is identified with the other: in fact, there exists no proof, anatomical or physiological, that authorizes us to assert the muscularity of either the ciliary body or of the processes. The very different functions which the iris performs, together with the peculiarity of its external appearance and internal structure, forbids us to consider it as part of, and identical with the ciliary body.

The extreme minuteness of several of the internal structures of the human eye, with the great difficulty that exists in procuring the parts, in a state sufficiently fresh to enable us to make observations so

precisely accurate, as the subject requires, greatly obstructs our endeavours to discover their intimate organization. In default, therefore, of practical proof by the knife, we are obliged to have recourse to physiological science, and to enlist on our side that powerful ally to anatomical enquiries, pathological observation. These remarks will, I think, be verified, when we come to speak of the iris, and its functions.

The breadth of the ciliary body, may be taken at about one line and one-third, the processes being about two-thirds of a line; their distance from the posterior surface of the iris, at half a line, although most anatomists have assigned a larger space.

The ciliary body and processes taken together, form a small concavity towards the vitreous body, to which they correspond; more plane, however, where facing the iris.

It has been a question, whether the extreme ends of the ciliary processes be, or be not inserted into the capsule that invests the lens. The anatomists of old times, with Galen, believed that they were so connected; both those who asserted and those who denied their muscularity. Heister, in his Dissertation on the Choroid, with Camper, Haller, and Zinn, denied the supposed insertion of the ancients; and I must incline to this opinion, in spite of the description of Meckel, who says, "Ils (Process: Cil:) s' attachent à la grande circonférence de la capsule crystalline par la partie antérieure de leur bord adhérent." It occasionally happens in the operation of extraction, for the cure of cataract, that on the

section of the cornea being completed, the lens surrounded by its capsule, suddenly makes its escape. In the instances where I have seen this occurrence, I have examined the capsule, without finding the faintest trace of the adhesion of these processes: and in a case, in which the lens was perfectly opaque, and the pupil so dilated that the iris was scarcely more than a line in breadth, it was easy to distinguish, through the space between the opaque lens and the ciliary processes, some small tubera, which were adherent to the posterior surface of the retina. This was in a child, suffering from soft fungoid disease of the eye.

The use of these processes, is wholly unknown; the many theories respecting their functions, fail in demonstration. Thus, the older writers who supported their muscularity, imagined the focal alterations of the eye were attributable to their agency. Others, that they assisted in the movements of the iris. Haller, that they served to keep the crystalline lens fixed in its situation. Ribes, in the Bulletin de la Faculté de Médicine, 1814, attributes to them the secretion of the aqueous fluid. This latter opinion we shall dilate upon, when speaking of the aqueous fluid, and its sources.

I believe the intimate structure of the ciliary processes, as well as that of the ciliary body, to be strictly and essentially cellular, possessing extreme vascularity; which, when they are seen floating in water, imparts a highly villous appearance; and when they are successfully injected, their resemblance to the valvulæ conniventes of a highly in-

flamed intestine, is strikingly exact. The vessels of this beautiful structure, consist of the various ciliary arteries, forming numerous arches with each other at the extremities of each process: the returning blood passes along the vasa vorticosa and ciliary veins. The arrangement of the blood-vessels of each single process, nearly resembles the nerves of a willow leaf, consisting of one principal artery, with numerous and intricate interlacements. From such an anatomical disposition, results the theory of the erectile nature of the ciliary body and process, by which some authors have attempted to account for the adaptation of the eye to vision at different distances. This explanation, is, to say the least of it, quite as probable as any other yet offered in elucidation of a, confessedly, very obscure, but not uninteresting subject.

IRIS.

The term, Iris, we find applied, by the oldest anatomical writers upon record, to that moveable curtain in the interior of the eye, which regulates the admission of light to the retina. Thus, Rufus Ephesius says, "Quod inter pupillam et album, iridem esse;" assigning as its boundaries, the interval comprised between its lesser and greater circumference; the white of the eye indicating here, the adhesion of the iris to the union of the sclerotic and cornea. Notwithstanding this apparently clear definition of position, and propriety of name, Galen, acting upon a singularly mistaken hypothesis, proposed to distinguish this structure by the term, "tunica cærulea."

In this course, Galen was followed by certain very able anatomists, amongst whom we recognize Casserius.

Fallopius and Vesalius subsequently restored the appellation given by Rufus, with the addition of the word *uvea*, then, and frequently even at the present day, applied to the posterior surface, where it is deeply embued with pigment; as contradistinguished from the *iris*,—a term strictly confined, by them, to the anterior surface of the membrane, and obviously derived from the brilliant and varied colours it presents. Varolius, in fact, applied the term to the colour solely, resulting, as he expresses it, from the uvea.

The iris is an imperfect membrane, its septum being pierced by a circular aperture, called the *pupil*. It is placed across the eye, dividing it into two unequal portions. It possesses a very remarkable property, a contractility inherent in itself, by which it enlarges or contracts the central opening of the eye, and this regulates the quantity of light admitted to the hinder part of the organ. The iris is fixed all round to the junction of the sclerotic and cornea; or to speak more exactly, through the medium of the ciliary circle, to which, in common with the ciliary body, it is firmly attached. For the sake of perspicuous description, we shall use the term, *greater circumference*, meaning the fixed or ciliary edge, and the *lesser*, or pupillary and free circumference.

From the ciliary circle, the iris stretches across the interior of the eye, as if it were about to form a complete division between the fore and hinder parts

of the organ: near the centre, however, it is perforated by an aperture, familiarly called the pupil. This opening is of a circular form, surrounded by the iris, incessantly varying in size, even in the same individual, at different periods, but always in strict accordance with the quantity of light required for distinct vision. This membrane is not convex; neither does it project forwards and towards the cornea, although a deceptive appearance, produced by its being seen through the aqueous fluid of the anterior chamber, would, if confided in, lead to the conclusion, that the surface of the iris is not plane. This circumstance was first demonstrated by Petit.

The breadth of the iris, if measured from the fixed to the free circumference, will be found to be unequal at different points or places. Thus Meckel and Cloquet agree, that the centre of the pupil is nearer to the inner than to the outer transverse diameter of the eye; which infers, that the iris is narrower towards the nose than at the temple: an observation first announced by Winslow, in the Memoirs of the French Academy, of the year 1711.

The colour of the eye is very various, yet seemingly having relation to the complexion, and to the colour of the hair. Thus, among the inhabitants of the torrid zone and arctic regions, who have equally dark skins, among brunettes, and natives of the South, generally, we have almost constantly a deep-brown iris; while in the more northern, but still temperate climes, the colour of the iris changes through all the various shades of blue, blueish-grey, light-brown and hazel. The dark-grey, brown, or hazel eye, is seen in com-

pany with all the shades of brown hair; but with red or flaxen hair, blue or blueish-grey irides are most frequently observed.

It is, however, quite unnecessary to go minutely into the subject of colours; still it may be remarked, that the pupillary margin is not unfrequently tinted differently from the rest of the iris, and that there are certain radiating and irregular lines traced upon its anterior surface, sometimes lighter, at other times of a darker hue, than the general ground of the iris. To this circumstance may be referred the peculiarity in the eyes of the French child, some time since exhibited in England, on whose irides it was pretended the words, "Napoleon Buonaparte," might be detected. I have myself seen a child, in whose eye a moderate effort of imagination might easily have converted these same radiating lines into definite letters at the pleasure of the observer. It sometimes happens, that the iris of one side differs totally in colour from the iris of the opposite eye.

The posterior surface of the iris, in appearance, differs considerably from the anterior; for while the latter presents a gay and brilliant tissue, shining in varied colours through the anterior chambers of the eye; the former is, invariably, found of a deep-brown or nearly black hue, occasioned by an abundant secretion of pigmentum nigrum upon its surface giving the name of uvea to that especial portion of the iris, which is free, or unconnected by direct attachment to the ciliary body. From this pigment is derived the determinate colour of the membrane; for if this black ground be washed off, or otherwise

cleared away, the colour of the iris is either wholly lost, or very much diluted and impaired. As was observed in regard to the adhesion of the pigment to the choroid, so, in this situation, it may easily be stripped off in shreds, or, on due care being used, even as an entire membrane; a circumstance that will subsequently afford us occasion to offer a few remarks upon the question, whether the iris be, or be not, invested with a serous membrane at its posterior, as well as at its anterior surface. Zinn, as will be seen by the following quotation, was aware of the possibility of separating the black pigment in a body; but obviously refers this to the consistence of the colouring matter itself. "Posterior iridis superficies semper, et in omnibus animalibus, obducitur pigmento fusco, crasso, solidiusculo, *ad pastæ materiam* magis accedente, ut in infantibus interdum, lævi agitatione in aquâ, annulus fere niger, inde secedere mihi visus est, albo iridis tergo relicto, ut suprà de corpore ciliari diximus."

It has been already observed, that the aperture, or perforation of the iris, is found of different diameters at different times, and under different circumstances, in the same individual. By what agency, by what faculty or power, is this remarkable result effected? I answer, by the muscular structure of the iris: and here occurs a point in physiology, long questioned and still undetermined.

It will be first necessary to describe, and if possible, to shew the form and situation of these, the moving fibres or muscles of the iris. Those anatomists, who assert their presence, agree in the

existence of two several sets of fibres, distinct in shape, in place, and in action: the one set radiating, and the other circular. The former is composed of those proceeding from the fixed, greater, or ciliary circumference, towards the pupillar or moveable one. The latter set, consists of those that surround the pupil.

The fibres of the ciliary circumference, whose action must necessarily be to dilate the pupil, are most conspicuous at the posterior surface of the iris; and may, every now and then, be distinctly demonstrated. They are arranged in minute folds, or plicæ, that suddenly terminate at the distance of about half a line from the pupillary edge of the iris. Examined under a microscope, they are observed to present bifurcated extremities, interlacing with the circular or pupillary fibres, in a manner similar to that in which the straight muscles of the face are interwoven with the orbicularis of the mouth. These fibres perform a similar office in restraining and regulating the circular muscle, which would, if unrestrained, nearly close the pupillary opening at each contraction.

The circular muscles are small, and scarcely perceptible fibres, situate at the anterior surface, surrounding the pupil, and by their contraction reducing the diameter of its aperture. They present a surface of about half a line in breadth, and constitute a true, and may with all propriety be considered and called, *sphincter iridis*. This relation is in strict accordance with the description given of them by Cloquet, in his "Elements of Special Anatomy." "Il a reconnu

à l'aide d'une forte loupe, que ces fibres forment deux sortes de plans; l'un externe, radié, plus large, dilateur de la pupille, et correspondant à l'anneau coloré externe; l'autre interne, plus étroit, composé des fibres circulaires, constricteur, ou *sphincter* de la pupille, et correspondant à l'anneau coloré interne."

When I attempt to prove the muscularity of the iris, I am aware of all the difficulties with which, in common with those anatomists who have preceded me in the same course, I have to contend: I know that the most perfect anatomical demonstration of fibres, that can be presented, although aided by the most delicate manipulation, will, and even ought, to fail to produce conviction, that the changes which the pupil undergoes are attributable solely to this cause; unless such fibres can be shewn to obey, under the greatest variety of circumstances, the known and recognised laws of muscular action. If, however, it can be proved, that the fibrous structure above described do respond to this criterion, under the influence of physiological and pathological relations, I certainly feel it competent to establish the actual and essential existence of muscular structure and of muscular function, in this most curious tissue.

The iris is capable of performing two several kinds of motion; namely, the approximation of the smaller to the larger circumference, producing dilatation of the pupil; and the contraction of this aperture, by the contraction of the sphincter, and the relaxation of its moderating fibres. This fact was remarked by Bichat, who observes, that it is an action the reverse of muscular contractility; inasmuch as the stimulus

produces elongation of the fibres (as in the contracted state of the pupil), and the absence of the stimulus an opposite state of parts, in shortening of the fibres. "Dans les tenèbres et toutes les fois, qui la lumière est très foible, il se contracte; et il en resulte l'aggrandissement de cette même ouverture; en sorte, qu' ici, le stimulant produit l'allongement de ces fibres, et son absence leur contraction—qui est absolument l'inverse des muscles." (Bichat.) If, then, it were impossible to explain away these observations of Bichat, the fact of the non-muscularity of the iris would be established, in consequence of the anomalous nature of this action, so inconsistent, and so opposed to all the avowed laws of muscular structure. I shall presume however, to attempt to controvert this opinion.

The circular fibres of the iris I consider as a simple sphincter, to be classed with the rest of the circular muscles possessing a power of contraction independent of volition, whose natural state is contraction; the essential and characteristic difference of this class, compared with the voluntary muscles, which only act during excitement, and whose contractile power is speedily exhausted by its continuance. Sphincter muscles, however, are under the control of the voluntary; which latter, by their contraction, are enabled to overcome the resistance opposed by the former. Generally speaking, the action of the sphincters is involuntary; yet, in different degrees, they admit of being stimulated to increased contraction by the operation of the mind. As examples of this order of muscles, we have the

sphincter of the rectum and of the bladder, respectively guarding these outlets during a total absence of volition, as in sleep, or when the will is not directed to the part: yet these are, under certain circumstances, overcome by the action of the levator ani, and the expulsive powers of the muscular bag containing the urine.

Again, the orbicular muscle of the mouth, is under the control of many and various muscles; yet in a passive state of these parts, the lips are closed. Another and more apposite example, is the orbicular muscle of the eyelids. In sleep, or whilst the voluntary muscle, the levator palpebræ superioris is quiescent, the lid drops; and during the total suspension of volition, the eye is defended from light and adventitious circumstances, by this action, altogether independent of the will.

It is thus by establishing the analogy between the circular fibres of the iris, and this class of muscles, that we hope to shew, how all the movements of this delicate membrane are dependant on the general laws of muscular structure. Yet it is important to state, that there is one circumstance peculiar to the iris, and not observable in any other sphincter muscle; namely, that the circular fibres, when contracted to their fullest extent, are still incapable of entirely closing the aperture they surround, while all the muscles before cited, concur to close the outlets they respectively protect.

In sleep, the pupil is much contracted, as may be seen by gently separating the eyelids of a sleeping infant in an obscure light. This provision, in a

manner most effective, and very beautiful, prevents the admission of so great a portion of light, as might rouse the quiescent retina; since it is well ascertained, that through the very substance of the eyelids such a quantity of this stimulus may be admitted, as to produce a very powerful impression, at times amounting to dazzling.

As distinct vision depends on the entrance of a certain proportion of the rays of light, whenever this portion is so much increased as to incommode or distress the retina, the radiating fibres relax, or rather *cease* from their state of contraction; the circular fibres then contract, and regulate the necessary size of the pupil, in order to guard the organ from the excess of stimulus. In the same manner, when the light is still further increased, the levator muscle of the upper eyelid gives up its office, and the lids close under the action of the orbicularis muscle.

Assuming that these fibres of the iris are truly muscular, we should naturally expect, that if one plan becomes palsied, the other would act with sudden power, and produce a corresponding effect upon the pupil; and such I have found to be the case. A very intelligent friend of mine, reported the following case of attempted suicide, shewing the effects of large doses of opium on the pupil. The patient, when first discovered after having taken a considerable quantity of laudanum, exhibited but few and feeble signs of life. The lips, and extremities of the fingers, were blue; the breathing was laborious, and drawn at long intervals, with spasm;

the pulse at the wrist, was scarcely to be felt; and the skin was without sensation; there was a total suspension of all voluntary motion. The lips and the eyelids, were firmly closed. *The pupil, on raising the lids, was found contracted.* The patient, after a lapse of nine hours, exhibited signs of returning animation, and ultimately recovered. In this case, we observe, that under the influence of so direct a narcotic, voluntary muscular power had altogether ceased; the involuntary muscles alone acted. The pupil was as much contracted, as if the straight fibres, in common with the rest of the voluntary muscles, had been palsied; whilst the circular fibres, or the sphincter iridis alone, were capable of contraction. A nearly similar case, in which death ensued from the effects of an opium suppository, was attended with similar results, as regarded the aperture of the pupil. The next very remarkable case, is an instance in which large doses of Belladonna, administered by mistake to a delicate female, had nearly proved fatal. The circumstances attending this error, were as follow:—Two pills, each containing five grains of the extract of Belladonna, had been swallowed in the absence of the surgeon, who, on entering into the sick room, observed the lady extended on a couch, apparently without life. The face, and the extremities of the fingers, were of a deep purple hue; the respiration was slow, and convulsive; in short, every symptom was present, indicative of approaching dissolution. On separating the eyelids, the pupil was found contracted to the minutest point: to use the expression of the surgeon, "*The pupil was a mere*

pin-hole." A result, of which the following, is, with all humility, submitted as a sufficient explanation.

In divided doses, or when externally or locally applied, Belladonna is well known to produce an enlarged, or dilated condition of the pupil: but, like a great variety of narcotics, may it not act as a direct stimulus, when administered in minute doses, causing contraction of the radiating fibres of the iris? While on the other hand, if it be applied in overpowering quantity, as in the case above related, it will instantly, and "*uno ictu,*" paralyze the voluntary fibres; while the sphincter iridis remaining unopposed, the pupil will become contracted in the highest possible degree.

Pathological observation points out, may I not say, absolutely demonstrates, the entire obedience of the iris to the recognized laws of muscular action. In apoplexy, the pupil has been generally described as in a state of dilatation. A remarkable case, among several brought into Guy's Hospital, exhibits an opposite state of parts. A man, whose brain, on post mortem examination, presented an enormous effusion of blood, filling all the cavities, and having broken down a large portion of the cerebral structure, was brought into the Clinical Ward, where he died in about twelve hours. On examination, the pupil was found gradually to contract, as voluntary power declined; and during the last hour of his existence, when sensibility was extinct, and voluntary motion had utterly ceased—the heart, alone, continuing to act, whilst respiration was slowly and most imperfectly performed by the diaphragm only—the pupil

was remarked to be contracted to the smallest perceptible opening. After death, the fibres again became lax, as in similar states of the system happens to all circular muscles;—a circumstance obviously and utterly subversive of the theory of an elastic ring surrounding the pupil.

At the London Ophthalmic Infirmary, during the years 1827 and 1828, I had occasion to observe two or three cases of palsy of the iris (to be distinguished, however, from tremulous iris, which has frequently been so named), in each of which, the circular muscle was alone affected; the pupil was consequently much dilated. The radiating fibres contracted to within two-thirds of their natural length; a space nearly equal to that, usually allowed for muscular contraction. As a consequence of this enlarged size of the pupil, a confused sense of dazzling ensued, the retina retaining its natural sensibility. In twilight, or during a very dull day, the patient's perceptiveness of objects was reasonably distinct. Under the influence of a gradual, but full course of mercury, all these cases perfectly recovered, the pupil ultimately recovering its primitive size and mobility. Under such circumstances as these, it appears altogether impossible to account for the condition of the pupil, as connected with a perfectly sensible retina, on any other ground, than the inferred existence of two several plans of muscular fibres, of distinct classes and relations. A different state of the pupil, may frequently be seen in cases of general palsy of the muscles, supplied by the third pair of nerves. Thus, when the upper eyelid is raised with

the finger, which no effort of the patient's will is capable of effecting through the medium of the now useless levator muscle, a fixed and contracted pupil is observed, evincing a participation in the affection of the muscles of the globe of the eye, and of the eyelids. This at least is usually the case, although, occasionally, the pupil is remarked to be simply without motion, in other terms, neither contracting, nor dilating; each series, or plan of fibres, being equally paralytic.

In addition to the above, I have been favoured with the following case, occurring in the practice of Mr. B. B. Cooper, at Guy's Hospital. A man was brought to him, having, as it was stated, fallen from a coach-box; he struck upon the vertex, and was taken up insensible. The man recovered his perception in about a quarter of an hour; but at the time of his being brought into the Hospital, he had again become insensible: his hands and feet were cold, pulse small and weak. *The pupils of both eyes were permanently contracted.* There was also a discharge of bloody serum from the right ear. Whilst the porters were carrying the patient into the ward, he was seized with an epileptic fit. The muscles of his whole body were thrown into violent contraction: he was convulsed for about a minute; his breathing then became stertorous, and the fit subsided. During the paroxysm, the pulse was scarcely to be felt, and the pupils were excessively dilated. As the excitement subsided, the pupils returned to the contracted state. Two fits followed, at the expiration of an hour, attended with the same phenomena. In this

case, the straight fibres of the iris were palsied, in common with the rest of the voluntary muscles; but under the spasmodic action of the epilepsy, they contracted with great force, and produced the excessive enlargement of the pupils, as observed by my friend Mr. Roberts, Jun. who carefully watched the case throughout.

It is well known, that all muscles acquire increased energy from exercise; that, in the arm of the blacksmith, or in the leg of the dancer, the greater degree of developement of the particular sets of muscles, is proportioned to the exertion required and exacted from them. So do we see in the iris, that if one plan of fibres be more constantly called into action than another, an habitual alteration of the size of the pupil is produced, indicating the increased amount of power acquired by the most frequently exercised set. Thus, in compositors, jewellers, watchmakers, and others, who are constantly in the habit of employing the eye upon minute objects at very close distances, the pupil becomes unusually small, ; and even when such persons are the subjects of amaurosis (a disease in which the pupil is generally much dilated), it most frequently happens, that the pupil still remains in this state of permanent contraction.

The circumstance, that we are not sensible of the operation of the mind in the varied movements of the iris, is not by any means an argument against the voluntary nature of its fibres; since every day experience proves to us, that the thousand muscular actions, necessary to the performance of our most

ordinary duties, are executed without our being aware of the direct operation of the will. Take for example, the operation of writing; innumerable delicate movements of the muscles of the hand and arm are essential to this end, and yet we are perfectly unconscious, in rounding the letters, of the action of the will in directing the contraction of each particular muscular fibre. Yet such is undoubtedly the case; and the whole is the effect of volition over muscles, confessedly voluntary, yet so rapidly conducted, as to leave us wholly unconscious of the exercise of this faculty.

Before I quit this subject, I cannot but mention the fact, that individuals have acquired a certain degree of voluntary power, independent of the ordinary use of the eye, in regulating the motions of their irides, so as to be able to influence the size of the pupil at pleasure. This circumstance is so well authenticated, and on such highly philosophical authority, as at once to preclude doubt. It suffices to mention the name of the late Doctor Wollaston, who had the power of controlling the motions of the iris, to establish another strong argument in support of the muscular theory.

Numerous facts and observations, both pathological and physiological, may be adduced and brought in aid of the theory, which I have ventured to enforce: but I am well content to confine myself to the cases above mentioned, in mere support of anatomical science; because, in determining the actual existence of muscular fibres, the knife and the microscope are confessedly inadequate in the delicate

texture of this membrane. Feeling strongly on this important portion of the subject, it becomes me to state, that I should consider myself as having acted with unbecoming temerity, if I had refrained from calling to my aid, the effects produced upon the iris by the influence of morbid changes, in the face, as it were, of the following observations of the celebrated Zinn, and of the illustrious anatomists whom he quotes. "Quicumque tamen nullâ theoriâ occupati proprius oculis iridem accuratius observârunt, in eo consentiunt, nullas se vidisse fibras orbiculares, etsi neque macerationis, neque microscopii adjumenta negligerent, uti post Meryum, et Valsalvam, Morganius, et illust: Hallerus discerte tradunt." (Zinn, c. 2. § iv.)

The opinion of so eminent an authority respecting the cause of the motions of the iris, admits, I presume to think, of easy refutation. From observations of the size of the pupil after death, in examples of the eyes of animals of the lower classes, Zinn concluded, that dilatation is altogether dependant on the elasticity of the longitudinal fibres of the iris, and that contraction necessarily and spontaneously ensuing on the relaxation of these fibres, is of course its natural state and condition. Now, elasticity is a principle equally inherent in dead, as in living matter; of course it follows, that, if the straight fibres of the iris be possessed of the property in question, the pupil after death, will always be found in a state of dilatation,—a condition altogether at variance with the observations on which the theory of Zinn is founded.

By other authors, the motions of the iris have been attributed to the more or less free afflux of blood into the arterial trunks, that ramify so minutely through its texture: or in other words, on "erectility of tissue."—I shall take an opportunity of making a few remarks upon this point, when we come to consider, in detail, the subject of its organization.

The anterior surface of the iris has been described as villous, and its varied colours have been assigned to that cause. It is remarked by Zinn, and by some other observers, that if this membrane be placed in water, and examined under a powerful lens, numerous villous points will be seen to float in the fluid, brilliantly coloured, like the pile of a rich velvet. This result, I have not been able to perceive to my satisfaction; on the contrary, it appears to me, upon this surface, as well as posteriorly, to be covered with a fine transparent membrane, to whose smoothness and exquisite polish, it owes its brilliancy in health, so readily distinguished from that loss of reflecting power and lack-lustre appearance, that forms so marked a feature in inflamed conditions of this tissue.

It has already been stated that the iris is plentifully supplied with nerves and blood-vessels; and although a description of the derivation of these important parts, does certainly more properly belong to another section of this work, when the contents of the orbit come to be treated of; yet it will be advantageous, perhaps even necessary, to say a few words on the subject in this place. The nerves of the iris are derived from the lenticular ganglion, and

from the branches of the first division of the fifth pair of nerves. These, the ciliary nerves, pierce the sclerotic coat by the numerous foramina, and traverse the oblique canals, spoken of in the description of that tunic. Having thence emerged, they may be seen proceeding from behind forwards, lying between the sclerotic and choroid, in sufficient number, and of so large a size, as to attract immediate attention. They are flat or ribbon shaped; and at the commencement of the ciliary circle begin to be indistinct, and cannot be followed through this structure with any success or satisfaction. At the insertion of the greater circumference of the iris into the ciliary circle, these nerves are again seen emerging, not however, in distinct trunks, but subdivided into branches diverging in order to inosculate with their fellows at each side; shortly, however, they again disappear in the thickness of the iris, and the more delicate manipulation fails in its attempts to pursue their ramifications in the human eye. In the eyes, however, of some of the larger quadrupeds, especially in certain birds, as the domestic swan, they may be traced through many inosculations, until they are again lost to our view, from their tenuity, faint colour, and pulpy consistence: still enough may always be seen by men even little practised in these pursuits, to excite their astonishment, and lead them to enquire wherefore so fine and delicate a structure as the iris is supplied with so extensive an apparatus of nerves. Notwithstanding the abundance of its nerves, the iris is not acutely sensible to pain. Wounds of this structure occasion but little

suffering; even extensive inflammation is sometimes wholly unattended with severe pain. It is also to be observed, that the concentration of the rays of light through a lens, produces no inconvenience or motion in this part, other than can be explained by the conclusion, that some portion of light traverses its structure and produces its usual stimulus upon the retina. On these facts, distinctly ascertained and generally agreed upon, may we not venture to conclude, that these nerves are principally destined to the functions of organic life, and to sustain the motions of this highly irritable structure?

The arteries of the iris, are still more numerous and intricate than the nerves, and present, with scarcely an exception, the most beautiful vascular disposition in the human body. They are supplied chiefly from two sources; namely, the long and anterior ciliary arteries, all branches of the ophthalmic trunk. The long ciliary arteries, two in number, after passing a short distance between the choroid and sclerotic coats, one on the nasal and the other on the temporal side of the eye, dividing it, as it were, by an equator, arrive at the greater circumference of the iris, before they have given off a single vessel. At this point, however, situated immediately beneath the anterior surface of this membrane, they both divide into two branches: the superior of which passes along the upper margin of the greater circumference of the iris, to meet its fellow; and the inferior, in an opposite direction, also to inosculate with the one of the contrary side. These four branches then surround the iris, and unite with what

anatomists have called the greater vascular circle of the iris. The vessels thus arranged, are tortuous, and receive, on their convex general aspect, several small anastomotic twigs from the anterior ciliary arteries. From the concavity of the circle a great variety of small serpentine branches pass, in a radiating direction, towards the pupillar opening, to use a familiar comparison, not unlike the manner in which the spokes of a wheel radiate from the felloe towards the nave. Prior, however, to these branches reaching the extreme edge of the pupil, they freely anastomose with each other, and with numerous smaller vessels from the anterior ciliary arteries; which, inosculating repeatedly by minute arches at the distance of about half a line from the central opening, constitute the lesser vascular circle of the iris. From the concavity of this circle, again, innumerable minute twigs radiate towards the centre, until they abruptly stop at the edge of the pupil. At this point, some anatomists describe another ring of vessels. This, however, in the most successful injections, I have never seen; although it is probable, some anastomoses may take place at this point, among the extremely minute and very numerous subdivisions of both long and anterior ciliary branches.

The anterior ciliary arteries, which number about twelve or fourteen, after having pierced the sclerotic at a short distance from its junction with the cornea, enter the texture of the iris deeper, and, in relation to its thickness, posterior to the greater vascular circle of the long ciliary, to which they send some

twigs of anastomosis. They then take a similar radiating course, from all points of the greater circumference of the iris, towards the lesser vascular circle, frequently joining with each other, and filling up the interstices left by the long ciliary arteries. Arriving at about half a line's distance from the pupil, they inosculate so freely, as to become undistinguishable from the branches of the long ciliary arteries; so that while the greater circle may be said to be composed almost wholly of the divisions of the long ciliary arteries, the lesser one is, with equal justice, said to be composed of both.

All the arteries that run from the circumference of the iris towards the pupil, take a somewhat serpentine or flexuous course, as, we may observe, do almost all arteries that surround openings, subject to frequent change of the size of their aperture. Familiar examples may be found in the coronary arteries of the mouth, or the palpebral vessels, that surround the fissure of the eyelids. This circumstance is worthy of our deep admiration, when we consider the liveliness of motion of the membrane they are distributed upon, and the extreme tenuity of the coats of these minute and beautiful arteries.

The blood is returned from the iris by straight and radiating veins, traversing the membrane in a contrary direction to the arteries, terminating either in the vasa vorticosa, as is most frequently the case, or in the ciliary trunks. These are called the *Iridien veins*.

Such is a rapid sketch of the vascular organization of this membrane, and I apprehend it will be sufficient to shew how freely it is supplied with blood,

and how various is the disposition of its vessels, on which has been based the theory of the erectile nature of this tissue.

It is supposed that the stimulus of light upon the retina, acting indirectly through the brain upon the iris, causes a rush of blood into the vessels of the part, producing increase of bulk in the iris, and consequent contraction of the pupil. The dilatation is accomplished by a return of this blood to the larger veins, aided by a supposed elasticity of the straight fibres. Were such elasticity present, we should invariably find the pupil dilated after death; and in the event of a rupture of a large vessel in the brain, as occurred in the case of apoplexy related above, we should, as the patient became more and more weak, and in the moments immediately preceding his death, expect to find, under this supposition, a manifest increase in the size of the pupillary aperture.

The most successful injections with size or spirit of turpentine properly coloured with carmine, never reddens the iris in the same degree, as either the choroid, or the ciliary processes; and, I have never yet observed the slightest contraction or diminution of the pupil to be produced in my most fortunate attempts to fill the greater and lesser vascular circles, a result which would probably ensue, were the erectile tissue present. Such injections do not often fail to raise the papillæ of the tongue, the nipple of the breast, or other structures of a similar class. I therefore confess, I feel strongly inclined to believe, that the muscularity of the iris, more strictly and

more perfectly coincides with pathological and physiological observations, than any other of the several theories, with which I am acquainted.

The existence of absorbent vessels in the structure of the iris has never been demonstrated, yet their presence may, with some shew of probability, be inferred by the phenomena of ulceration, and by the result of the various morbid processes incident to this tissue.

RETINA.

The structure next presenting itself in order, is that nervous expansion which lines the posterior portion of the globe of the eye, called retina.

Upon this membrane are first received all impressions made by the rays of light, transmitted or reflected from every luminous or visible body, collected and condensed, or in whatsoever manner modified, by the dioptric media or humours of the organ: impressions thus formed, are communicated, by means of the optic nerve, from the retina to the brain, in which perception is produced, or where strictly speaking, true vision takes place. The retina, therefore, like the nervous apparatus of the other organs of sense, is the primary expansion, or surface, upon which impresssions from external bodies are received, and whence they are transmitted by means of a nervous trunk, that terminates in the true percipient organ, the brain. From the time of Hippocrates, this medullary structure has been classed amongst the tunics of the eye; improperly, however, if we

are to understand the term in its true and rigorous sense; because the retina, instead of being destined to support, or defend any portion of the contained mechanism of the eye, seems to be of far superior importance; all other parts being subordinate to it, and lending their combined aid, to preserve to the retina, its integrity in the due performance of its function.

The earlier accounts of this tissue are somewhat confused and embarassed with various names, which, however, seem all more applicable to the vascular portion of the retina, than to the membrane itself. Thus Celsus, who classed it amongst the tunics of the eye, uses a name given to it by one of the earliest anatomical writers. In the Seventh book "de Medicinâ," he says, "Deinde infrà rursus tenuissima tunica, quam Hierophilus αραχνοειδην, nomi navit." Another appellation given to this structure, is that of "amphiblestroides," used both by Rufus, Ephesius, and by Galen. The term, however, by which we are accustomed to distinguish this part, is "retina," synonymous with the Greek term "amphiblestroides," in sense and intendment, not dissimilar, to the more early words "arachnoid" or "aranea."

Without wishing to appear fastidious on the subject of the terms made use of by different authors, I must beg permission to remark that the word retina, as well as all its synonymes, has been applied to this membrane, from a supposed resemblance to a net; the vascular web of this, or of any other tissue, may possibly be likened to a net-work, but the nervous organ itself, bears not the slighest similitude to

that apparatus, from whence the name has been derived.

The retina, taken in its common acceptation, is not a simple membrane, but divisible into the medullary and vascular portions, which latter has, somewhat unadvisedly, been elevated into the rank of a separate tunic, essentially belonging, however, to the former; the outer periphery of the retina, is invested by another structure, called after its discoverer "Tunica Jacobi." This in the natural order of investigating and dissecting the parts, would necessarily come to be described in this step of the process, were I not induced, for the sake of perspicuity, to defer its consideration until I have completed my analysis of the retina itself.

The retina is placed within, and is concentric to the choroid, having the same limits as to extent with the latter. It may be traced from the point where the optic nerve enters, up to the termination of the choroid in the ciliary body. It is of a pulpy texture, and extremely delicate; so much so, indeed, that but from the support it receives from the membrane of Jacob, and its own vascular web within, it would appear upon dissection a mere brain-like pulp: for as Galen observes, if it be beaten into a mass, it would not differ in any particular from an equal quantity of the white medullary substance of the brain.

In the living subject it is perfectly transparent, allowing the black surface of the choroid to shine through, accounting thus for the intensity of colour in the pupil. Shortly after death, instead of the transparent structure which the retina exhibits in

the living body, we find it to have acquired a certain milky hue, which changes gradually to a lilac whiteness, while viewed in its relation to the choroid; separated, however, from this membrane, and the deep black ground of the pigmentum nigrum, it presents a faint yellowish-white, semi-opaque aspect. The retina appears to decrease in thickness towards its anterior edge, and though in opposition to so excellent authority as Zinn, who maintained the equallity of its thickness, and uniformity of substance throughout, I hold, that, contiguous to the spot at which the optic nerve enters, it is manifestly of greater thickness than at any other part; here also it becomes more opaque after immersion in rectified spirits. The anterior portion of the retina, or as some say its termination, at the ciliary body, is formed, not by a plane edge, but presents a scalloped border, which corresponds to the "ora serrata" of the ciliary body; this appearance may most readily be displayed, by suspending the retina from the optic nerve in dilute spirit of wine, and carefully stripping off the choroid membrane as far as the ciliary body, when the semilunar indentations of the anterior edge of the retina, will be found to correspond with the convexities presented by the serrated border of the ciliary body.

Several of the older anatomists, amongst whom we find the names of Ruysch, and Briggs, assert that the retina is composed of minute fibres, evidently derived from the fibrous appearance of the optic nerve, and thence radiating in the form of a star. Haller denies this, and attributes the appearance in question, to certain plicæ or folds, into which

the retina probably falls, by the evaporation, or dispersion of the fluid of the vitreous body after death. It has assuredly never happened to me to observe any fibres, or any appearance that could be mistaken for fibres, in a recent *human eye*, nor, always supposing the dissection to be made from a recent subject, any folds or plicæ assuming a fibrous form. One fold, as we shall presently see, does indeed always exist, but never, so far as I have remarked, resembling the fibrous arrangement described and drawn by Ruysch. The following is the expression of the illustrious Haller, " plicas in retinâ radiatas potius, quam fibras distinguo;" which appearance I believe only to exist after a continued immersion in spirit of wine, which contracts and corrugates this delicate membrane.

Respecting the anterior termination of the retina, anatomists are much at variance; they, however, all agree in fixing its origin at the point, where the optic nerve enters. For myself, I should be disposed to place it at the anterior border, could we, with any propriety, determine the precise point of origin of any single membrane in the body. The established form of description commences with the optic nerve, which throws off its fibrous covering at the place, where it becomes lodged in the hollow of the sclerotic. It does not then immediately perforate this coat, but is stopped at the bottom of the short canal, by the lamina cribrosa, anterior to which, it is said to form a small pad or button, whence the retina expands concentric with the choroid, and passes towards the anterior part of the

globe, investing the vitreous body. Its connection with the nerve, has frequently been compared to the spherical expansion of a portion of melted glass blown from the extremity of a tube: such a similitude may assist the mind in forming an idea of shape; generally, however, it proceeds further, suggesting an identity of structure and formation, as existing between the optic nerve and expanded retina. This conclusion I apprehend to be inadmissible; in point of fact, the retina receives the impression, the nerve conveys it; but that the latter has not the faculty of receiving the impression is proved by an experiment, first mentioned by M. Mariotte, shewing that the place, where the two structures may be said to unite, being the exact spot where the nerve enters, is insensible to the stimulus of light, although that stimulus may be sufficient to produce dazzling in any portion of the retina.

I have already stated my belief that the retina is bounded anteriorly by the union of the choroid with the ciliary body, and ciliary circle; the opinions, however, both of ancient and modern authors are at variance on this subject; thus, Galen, amongst the ancients, affirms the termination of the medullary structure to be at the circumference of the lens, into which it is inserted. In this doctrine he is followed by Winslow, Lieutaud, Ferrein, and Haller; the latter author indeed speaks somewhat doubtingly, as to whether it may not even cover the lens itself. "Ad lentem hujus properat, in capsulam innata, *et huic obducta*, si fides quorundam experimentis haberi potest." Vesalius, as by reference to the plate of

this anatomist is clear, represents it as proceeding scarcely further than the centre of the eye; and he observes, "dilatatur in latum quoddam involucrum, posteriori vitrei humoris sedi obductum, et non multum ultrà mediam oculi sedem, in anteriora pertinens." Plempius, Briggs, Morgagni, and others, followers of Albinus, agree in the termination of the retina at the ciliary circle. Among the moderns we have an equal variety of opinion; Monro agrees with Galen; Cloquet asserts, that a very thin and pulpy layer passes in contact with the ciliary body, is stained by the interstices of the ciliary processes, and finally arrives at the circumference of the lens. This is the opinion, and given in nearly the same words, of Bichat. Sir C. Bell does not affirm that the pulpy substance of the membrane proceeds so far, but that "we may safely say, that the membrane which supports the retina (tunica vasculosa), is continued over the lens, and forms part of its capsule." From an authority so eminent as Sir C. Bell I dissent with great reluctance; and in a subsequent part of the treatise I shall assign the reasons by which my mind is led to a different conclusion. I adopt the observation of Meckel, who says, speaking of the retina, "qui se termine en avant, à l'extrémité posterieure du corps ciliare, par un bord, plus ou moins sensiblement renflé, entre lequel et la capsule du cristallin, il n' existe aucune connexion." To this passage is appended an admirable note, too long, however, for insertion in this place, but of which I earnestly recommend the perusal to my readers. (Manuel d'Anatomie Generale, tom. III. p. 238.)

In the description of the sclerotic, I had occasion to notice the lamina cribrosa, and the point where the optic nerve enters, as not being placed in the direct centre of the eye; or, in other words, not in the exact axis of vision, but being rather to the inner or nasal side of the organ. If the globe of a recent human eye be divided by a transverse section, and, whilst immersed in water, the vitreous body along with the anterior section be removed, the posterior portion of the retina will be brought into full view; which, notwithstanding the delicacy of its texture, will remain undisturbed, and fairly exhibit the lateral entrance of the nerve. From this point, we at once trace a small elliptical fold, that extends transversely to the very axis of vision; where is observed in its centre, a small dark spot, not perfectly round, but rather oval, like the fold in which it is placed; it is also slightly depressed, and surrounded by a yellow circumference. This spot is what Soëmmering discovered, and described as the "foramen et limbum luteum," and which, during several years, was considered peculiar to man: but Cuvier has since remarked it to prevail in some of the genus, "quadrumana;" and by Dr. Knox, it has subsequently been observed in the eyes of certain lizards, and in the chamelion; the last mentioned author has denied the appearance of a fold in the human eye, and treats its existence, only as a *post mortem* result. I, however, believe the fold to be essential to the formation of the dark-coloured spot described by Soëmmering.

A contrariety of opinions has existed in reference

to this point. The illustrious author of the discovery, by the very name he has applied to it, considers it as a real aperture, surrounded by a yellowish coloured circumference; while Blumenbach attributes to it an expansive and contractile power, for the purpose of regulating, under certain circumstances, the admission of rays of light. Sir C. Bell denies the existence of a real foramen, the apparent aperture being produced by the transparency of the retina at this point, while its remaining portions become uniformly opaque. Blainville, in his Principes d'Anatomie comparée, though generally correct in his description of this appearance, falls I believe into a similar error; "Un petit enfoncement plus ou moins ovalaire, translucide au milieu, autour duquel se plisse un peu la rétine, qui l'on remarque dans cette membrane, en quelque distance en dehors de l'entrée du nerf optique, dans l'axe même du globe de l'œil." For myself, I am disposed to think, that the existence of the *apparent* aperture in question, may be explained on other grounds, than that of the transparency of the central spot. I have remarked, that it is not, as Soëmmering has represented it, a perfectly circular point, but that its figure is oval, corresponding in this respect with the plica, in the centre of which it is placed: this is also stated by Blainville. This fold is formed by a duplicature of the retina, or rather by the union of two minute plicæ, united at their respective extremities, and leaving a depression between them in their centre. Their extremities thus joined, extend on the one side to the entrance of the optic nerve, while on the

other, or temporal side, they are lost by expanding into the general surface of the retina: the extreme length of these folds is about one and a half lines, in breadth nearly one line. This appearance I have repeatedly observed in the human eye, when immersed in water, as I have already described. If the subject under observation be carefully frozen, and neatly separated by a vertical section through the centre of the folds, it will be still more distinctly shewn, and exhibit the central depression, consisting of a single layer of retina only; whilst the folds consisting of two portions of membrane doubly opaque, and standing out in relief, throw it into shade, the dark pigment behind, adding a still greater depth of colour, increases the effect of the shadow.

This conclusion is still further sustained by the appearances exhibited by a preparation in my possession, in which, by long immersion in dilute spirit of wine, the central depression has partially unfolded, shewing the continuity of the retina between the folds as perfectly opaque as in any other portion of its surface. The yellow circumference, or "limbum luteum," has been also blanched by the spirit, a result, as to colour, equally produced on the grey matter of the brain by long continued immersion.

The opinions which I have here ventured to submit to the profession, are the result of dissections made six years ago, the vouchers for which I still retain in the preparations then made: they have been confirmed by recent and continued examination of this point; and as the inspections afforded me, on these

occasions, were made under circumstances the most favourable, as regarded the recent state of the organ, I am led to speak, with increased confidence, of the nature of the appearances described in the preceding paragraphs.

It may not perhaps, be uninteresting to the reader, to detail in this place, the method by which this fold of the retina may be most distinctly exhibited. If, at from twelve to eighteen hours after death, we remove the globe of the eye, being careful not to subject it to pressure in the extraction from the orbit, and having divested it of its muscles, and cellular capsule, immerse it in a mixture of pounded ice and salt, in a short time the subject will be sufficiently solid for our purpose, and we shall be enabled to make the required section with considerable facility. This should be done with a sharp and very thin bladed knife, such as is commonly used in the extraction of the cataract. The course of the incision should be from above downwards, dividing the sclerotic and cornea, and the eye itself, into two lateral portions, by a vertical section through the very axis of vision. If, perchance in this manipulation, we should not have succeeded in hitting the precise centre of the fold, we shall still be sufficiently near to observe its exact position; and by another thin slice, entirely accomplish our purpose. With some trifling modifications, according to different subjects, the folds will then present themselves, divided transversely, exhibiting a central depression anteriorly, whilst, at the posterior surface, there will probably, be found a small quantity of pigment insinuated

between the edges of the retina, as it dips to form, by its reduplication, the folds we have described. The central hollow will, generally, appear more shallow, and the edges of the folds will seem to be more flattened in the frozen eye, than in a subject not submitted to congelation, in which, if by a fortunate accident, the folds have been precisely divided under water. The explanation of this circumstance is probably as follows: when the vitreous body begins to assume a solid form, it expands and presses against the resisting sclerotic; the retina, not yet sufficiently firm to preserve its form altogether entire, is pressed with some force between the expanding vitreous body, and the external membrane of the eye. The fold becomes, in consequence, somewhat flattened, and a minute quantity of pigment is squeezed between the separated portions of the folds behind.

It is hence apparent, that, in conducting the observations above described, it is important that an eye be selected for the purpose, with a due regard to its freshness, lest, by evaporation, or transudation of the contained fluids, the retina may have lost that uniform fullness, which it possessed during life. The process of congelation, also, should be performed with the least possible delay, and may, indeed, be generally accomplished within a period of ten or fifteen minutes.

Vascular structure of the Retina.

Upon the inner surface of the retina, and contiguous to the vitreous body, the vascular net-work is

described as the "tunica vasculosa retinæ." Of the existence of this, a separate and distinct membrane, I do certainly more than doubt: that the blood-vessels, which supply and support the retina, are distributed upon its inner periphery, I am perfectly prepared to admit, and in their ultimate ramifications they form a minute and delicate web, in structure and function somewhat similar to the pia mater, in reference to the brain. Such was the opinion of Monro, and in this I concur. Several, however, of the best anatomists of the present time admit and assert its presence as a separate and distinct membrane. Zinn remarks, that no human hand is competent to separate the vascular tunic from the retina, although the pulpy matter may, by maceration, be entirely washed away, leaving the vessels "in situ," and giving more or less the appearance of a vascular net-work, whence the name of the entire structure was originally derived.

The ophthalmic artery gives off a small branch early in the orbit, known by the name of "arteria centralis retinæ," which penetrates obliquely the sheath of the optic nerve, about three quarters of an inch prior to the entry of the nerve through the sclerotic. The artery then becomes placed in the centre of the nervous bundles, and finally passes, either in a single trunk, or in two or three minute subdivisions, through the lamina cribrosa of the sclerotic coat. The principal divisions of the central artery, are, *first*, one which penetrates the vitreous body, with which we have nothing to do in this place; and *secondly*, two which pass, the one

above, and the other below the optic nerve, taking a sweep at first slightly towards the nasal side, and then curving to the temporal side of the retina, form a sort of incomplete circle, in the centre of which we see the fold and spot of Soëmmering. The direction of these branches, is constantly towards the anterior edge of the retina, where they again subdivide, taking as it were the circuit of its extreme border. From the concavity of these main branches, numerous subdivisions are given off tending towards the centre of the membrane, which anastomose frequently with each other. From the convexities of the principal branches, again, various minute arteries are distributed to every part of the general surface of the retina, but always having a tendency forwards. They inosculate repeatedly, and constitute the arterial web of this organ. Lastly, from the anterior side of the branches of the extreme border, some very minute twigs may occasionally be detected, passing still more forward, up even to the very circumference of the capsule of the lens, in this way accounting for the anterior layer of the canal of Petit. Having ventured to deny the separate and independent existence of the vascular tunic, it becomes incumbent on me, to account in some other way for the formation of this canal; this topic, I propose to discuss in a subsequent section of this work. The divisions of the central artery of the retina, are formed at first between this membrane and the vitreous body, subsequently embedded in the medullary matter itself, and almost shut from view when the retina has become opaque; and finally, at

the extreme anterior edge, they are seen placed somewhat on the exterior of this structure.

The veins of the retina are distributed, both anteriorly and posteriorly, after the manner of the arteries, and perforate the lamina cribrosa, as venæ comites of the central artery. These veins are less numerous, but larger than the arteries, and are sometimes found, after death, gorged with blood.

According to the opinion of Sir E. Home, *a minute absorbent vessel* passes through the foramen of Soëmmering. This, however, can scarcely be possible, since I believe no such aperture exists; again, because no absorbent vessels have hitherto been discovered in the eye; and it would, if the aperture did exist, and the absorbent was proportioned to the apparent dimensions of this point, be barely possible that it should uniformly have escaped the eyes of so many searching anatomists that have treated on this subject, more especially since their attention has been called to it. It may, also, be remarked, that absorbents usually take the course of the blood-vessels; and consequently we ought rather to seek for their presence, in the direction of the central artery of the retina, or of the ciliary arteries.

The Optic Nerves.

Tracing the optic nerves backwards to the brain, may appear an unnecessary deviation from the usual plan adopted by anatomists; but, I trust, I can upon physiological principles point out sufficient reasons to justify me in assuming such a course.

The general, nay universal opinion of anatomists, regarding the cerebral nerves, has been up to a very late period, that they invariably take their origin from the brain, from whence the description of them is made to commence. Some anatomists of modern times, such as Monro secundus, and M.M. Gall, and Spurzheim, appear to doubt whether the nerves arise or terminate in the brain; yet they uniformly commence their relation of these cords from the brain or encephalic mass, and spinal marrow. It would seem more consonant with physiology, were we to make some derivative distinction between the nerves of the senses, and those of volition.

The spinal nerves are attached to the spinal cord by two roots, possessing distinct and independent functions: the anterior, destined to obey the commands of the will; the posterior, subservient to the purposes of sensation. Thus when we will a motion, the muscles obey, directed by an impulse conveyed from within, by a nervous cord, to the moving fibres situated at a distance: but, contrarywise, when we receive a blow, or lay our hand on a body to ascertain its form and feel its texture, the impression is conveyed from the periphery to the centre, by the posterior roots, terminating, not beginning, in the spinal marrow. It would seem, therefore, to agree better with the functions of the nerves generally, were we to assign the origin of such as are the agents of the will, to the brain and spinal cord; while, we fix the termination of those, that form the channels through which the impressions become perceptions, in the encephalic mass, and vertebral

marrow; their origins, or rather their commencements, in the parts destined to receive the primary impressions.

Thus, the gustatory nerve will be first found in the sensitive papillæ of the tongue; the optic nerve, by a parity of reasoning, in the retina, which is first destined to receive the impressions of its own peculiar stimulus, light. Although both arterial and venous trunks are attached to the heart, ought we to consider both as originating in this organ? No one, I believe, describes a vein as commencing in the auricle, or thinks of tracing its course from this part; no one describes the vas deferens, as arising from the vesicula seminalis, or the parotid duct, from the lining membrane of the mouth. If then, we follow the physiological law, in giving our anatomical relations of a part, we may fairly trace the optic nerve, in common with all the nerves of the senses, from the recipient organ of the impression, backwards to a termination in the brain, where that impression becomes perception, or where the function or sense of vision is finally completed.

The optic nerve, while in the orbit, is a round compact cord, encased in a strong fibrous sheath, and continuous at the one extremity with the sclerotic, at the other with the periosteum of the orbit, and dura mater of the cranium. While enclosed in this dense covering, we find the nerve divides into a multitude of little fibrils, each closely invested with a fine cellular membrane, analogous to the pia mater. These fibrils have their commencement at the lamina cribrosa of the sclerotic; they do not, however,

pierce it in order to enter the eye, but at this point, seem rather to lose both their investment and fibrous appearance, as if, merely, the medullary structure of the nerve and retina were here continuous, or that the retina had collected at this point, and passing through the holes of the fibrous plate, had become suddenly encased in small sheaths, giving to the whole an interwoven cord-like appearance.

At first the nerve is small, and convex at its point, owing to the shape of the narrow canal hollowed in the thickness of the sclerotic, and appears as if girt by a ligature, separating it from the retina. Escaping from this canal, which is scarcely two lines long, it becomes fuller, more round in the form, and less dense in its texture. Its fibrils are more numerous, and apparently anastomose frequently with each other; they are freely supplied with blood, in part from the minute branches of the arteria centralis retinæ, which pierces the nerve obliquely, and is lodged among its fibrillæ; and also in part by branches, which ramify on its external fibrous sheath.

The nerve covered with its sheath is rather more than two lines in diameter, and proceeds in a tortuous course towards the inner and hinder portion of the orbit; in fact, the nerve is longer than would barely reach from the back of the bony cavity to the globe of the eye. Its length, and its deviation from a straight course, are obviously to allow of the various motions of the globe without injury to its structure, as well as to prevent any tension that might otherwise interfere with the due performance of its function.

Near the globe, the optic nerve is surrounded by the ciliary arteries and nerves; near to the posterior extremity of the orbit, at its external and upper edge, it is in relation to the lenticular ganglion, from which most of these nerves arise. It is crossed from without to within, by the ophthalmic artery; and is separated in the greater part of its course from the muscles that give motion to the eyeball, by the interposition of much cellular and adipose membrane. When it has arrived at the posterior and inner portion of the orbit, it is surrounded by, and its fibrous sheath is connected with, the origin of several of the muscles that move the globe. It, finally, escapes into the interior of the cranium through the optic foramen of the sphenoid bone, by which the ophthalmic artery enters the orbit: at this point, the fibrous investment is continuous with the periosteum lining the orbit, internally, with the dura mater of the brain.

When we trace this nerve within the cranium, we find it pursuing a course, directed backwards and inwards, converging towards its fellow of the opposite side, and which it finally meets at the processus olivaris of the sphenoid bone, immediately anterior to the pituitary gland. Up to this point the nerve has been gradually losing its fibrous appearance, and since its entrance into the cranium, has become much softer and flatter than before. At the spot where both nerves appear to unite (in what manner we shall afterwards consider), the structure appears homogeneous, white, and strictly medullary. Its form and present firmness are, here, owing very considerably to the investment of arachnoid membrane,

reflected off the dura mater, precisely where the nerve entered the skull, and lost its fibrous sheath. From the junction which occupies a space of about four lines in length and breadth, the nerves are again seen to diverge towards the posterior part of the brain, taking a course somewhat under, and concealed by the middle lobes; surrounding, in what is called the "tractus opticus," the external edges of the crura cerebri, and ascending by a gentle curvature, to be connected with the posterior part of the optic thalami, and to terminate in the corpora quadrigemina.

The optic nerves in the above course, are in connection with many parts of the brain. At the immediate point of their junction, they communicate with the grey matter placed around the infundibulum; with the grey matter of the third ventricle, and in their "tract" with the substance of the middle lobes of the brain, and with the fibres of the crura cerebri: while ascending, at their upper curvature, they are in communication with the grey matter of the corpora geniculata, externa and interna; with the corpora quadrigemina, especially with the posterior: terminating in the superficial white layer of the optic thalami. Finally, these nerves are again brought into union with each other, by means of the posterior commissure, and the transverse white bundles uniting the corpora quadrigemina.

Such is a rough outline of the cerebral communications of these cords: we shall return to this subject when treating of the optic nerves in particular, as many interesting points are connected with the

developement of the cerebral structure; more especially with the commissures, upon which, I believe, mainly depends the phenomena of single vision with a double organ.

In a physiological, as well as in a pathological point of view, there are no parts connected with the organ of vision that demand a stricter enquiry, than the relation which the external mechanism bears to the nervous structure, and its communications with the various parts of the encephalic mass. This enquiry more strictly belongs to the experimental physiologists and morbid anatomists: we shall, therefore, stop only to consider in this place, the mode of junction between the two nerves, in their position between the anterior clinoid processes.

There have been, at various times, three different opinions on this particular point, supported by the most eminent authorities.

Firstly.—That the two nerves merely unite by an intermediate band in the form of the letter H; the nerve of the right eye proceeding to the right side of the brain, having only a cross band of communication with the left nerve.

Secondly.—That the nerves actually cross each other in the form of the letter X.

Thirdly.—That a combination of the two former modes takes place, or that part of the fibres of the right side unite with the brain at the same side, and part cross to mix with the opposite nerve; and so, *vice versà*, with regard to the left nerve.

Each theory has had its friends and advocates, men of undoubted powers and authority; founding

their belief on the deepest and most varied research; the most minute enquiry into the appearances presented in health; by laborious dissection, morbid change, and experimental physiology. Yet notwithstanding the almost exhausted state of the subject at issue, no fixed opinion yet exists.

Galen and Vesalius agree in believing, that the mode of union operates on the first principle; and the latter author gives a remarkable case and drawing, where the two nerves not only did not cross, but did not even touch each other; merely approaching, and then quickly separating to pass through the foramina of their respective sides. The following is the singular history he gives. "His ille accessit, cujus nervos visorios illo de quo hîc sermo est, congressu invicem non connasci, neque sese contingere vidimus; sed dexter non nihil eâ sede, quâ calvariam egressurus fuerat, sinistrorsum, et sinister non hihil dextrorsum reflectabatur; quasi non coalitus occasione nervi congrederentur verùm ut commodè per suum foramen e calvariâ prociderent." This belief of Vesalius was further strengthened by his observing a case in which the optic nerve of one eye was atrophied in the same line on each side of the junction. Santorini also quotes an observation in contravention of the theory of the decussation, in which he describes an optic nerve, both before and after its junction with its fellow, of a grey cineritious hue, while the nerve of the opposite side presented its white colour throughout its whole extent. Le Cat states, that both optic nerves unite, as it were, into one trunk or nerve, without crossing or inter-

mingling.—This opinion is also entertained by Vicq d'Azyr and Monro.

The second doctrine has also been asserted by several eminent authorities, amongst whom we find the most celebrated writers of almost every age—Swammerdam, Petit, Haller, Willis, Soëmmering, Walther, and Cuvier. Morgagni quotes an observation of Valsalva, in which it is remarked, that a morbid change in the structure of that side of the brain to which one of the optic nerves was attached, destroyed the vision of the eye at the opposite side. Soëmmering traced an atrophic state of the nerve to the opposite side of the brain, in seven instances, in which one of the eyes had perished. Wenzel describes an affection of the optic nerve of the one side, invading the opposite nerve, on the cerebral side of the junction. Cuvier has preserved a preparation of a similar nature in the horse; in this animal, also, I have had occasion to observe a like result. The crossing of the optic nerves appears to be confirmed by the experiments of Rolando; for if we deeply wound either the cerebral hemispheres, or, the corpora quadrigemina, the eye of the side opposed to the wound thus made, becomes paralytic. Serres in his "Anatomie Comparèe du Cerveau," concurs with this view of the subject. If we descend in the scale of animal life, we find the natural appearances of this portion of the nerves to confirm the theory of the decussation; and in a great number of fishes, the nerves not only cross without confusion, but do not even come in contact with each other, being separated by a strong fibrous plate; so that nothing can

be more evident, than that the nerve of the right eye does actually pass to the brain on the left side, crossing the tract of, but not touching the left.

Thus we have observations of healthy structure, pathology, and physiological enquiry, at complete variance with each other, the upholder of each theory warmly combating the other's arguments, each firmly confiding in the result of his own experience. Hence has arisen a third class of observers, neither altogether denying, nor admitting, the facts stated by either of the two former, but founding a distinct hypothesis, assuredly not without its share of merit.

The nerves, say this third sect, neither pass wholly to the same side of the brain, nor do they wholly decussate; but the exterior fibres of the one side maintain their original direction, while the internal bundles pass over and become the internal fibres of the opposite side beyond the junction. Wenzel mentions a case, where the internal portion of the nerve traversed a quantity of grey matter situated at this place of junction, and visibly crossed to the opposite side. Cases of partial atrophy, anterior to and behind the crossing, as described by Ackerman and Morgagni, attest the probability of this formation.

From a consideration of the healthy nerves, I incline to the latter opinion; but I also believe many of the internal fibres of each nerve to be lost at once, by communicating with the grey matter situated round the infundibulum, and the floor of the third ventricle, to which points the junction of the nerves

is strongly adherent: as well also, as because the nerves become visibly smaller at the cerebral side of this spot, giving weight to the supposition, that a considerable quantity of the fibres are, in fact, not continued beyond this place. I can also readily conceive, that both the two former states of junction may occur in distinct and separate instances, without giving ground to infer derangement of vision: more especially, since the ultimate union operates on the brain, as before mentioned, by the posterior commissure and the transverse fibres of the corpora quadrigemina. In fact, although Spurzheim believed that the singular case related by Vesalius, was only a violent separation of the junction of the nerves, still the latter made very close enquiries as to the extent of vision enjoyed by the subject of this unusual state of parts. He found the function perfect, as he thus expressly states,—" Quàm ipsum de visu nunquam conquestum fuisse, visuque præstante semper valuisse, familiaresque de visorum duplicatione nihil unquam intellexisse."

Hence it follows, that some rare instances may exist, where the nerves pass respectively to the same side of the brain, without crossing, without any symptoms existing during life to lead us to suspect any unusual organization.

Secondly.—That, in most instances, some of the external fibres of the nerve maintain the same direction behind as well as anterior to the junction; and

Thirdly.—That pathology distinctly points out the fact of so great a number of fibres actually crossing to the opposite side, that deep injury to the optic

thalami or corpora quadrigemina of the one side, will almost invariably palsy the eye of the opposed side.

Jacob's Membrane.

By reference to all anatomical works of acknowledged authority, it appears, that up to the year 1819, the retina was universally considered to be composed of two laminæ only; the pulpy or medullary substance, in contact with but unattached to the choroid and the inner layer, described as the tunica vasculosa, investing its inner surface and interposed between it and the vitreous body. In the year 1819, Dr. Jacob of Dublin, communicated his discovery of a third membrane, investing and supporting the medullary tissue of the retina. I need scarcely apologise for introducing on this occasion the description of this interesting and delicate discovery, which Dr. Jacob has given to the public, in the Transactions of the Royal Society.

"Exclusive of the two layers," says that anatomist, "I find that the retina is covered on its external surface by a delicate transparent membrane united to it by cellular substance and vessels. This structure, not hitherto noticed by anatomists, I first observed in the spring of 1818, and have since so frequently demonstrated it, as to leave no doubt on my mind of its existence as a distinct and perfect membrane, apparently of the same nature as that which lines serous cavities. I cannot describe it better, than by detailing the method to be adopted

for examining and displaying it. Having procured a human eye, within forty hours after death, a thread should be passed through the layers of the cornea, by which it may be secured under water, by attaching it to a piece of wax previously fastened to the bottom of the vessel. The posterior half of the sclerotic being first removed, with a pair of forceps in each hand, the choroid should be gently torn open and turned down. If the exposed surface be now examined, an experienced eye will perceive, that it is not the appearance usually presented by the retina; instead of the blueish-white, reticulated surface of that membrane, a villous structure, more or less tinged with black pigment, presents itself. If the extremity of the handle of an ivory dissecting knife be pushed against it, a breach is made in it, and a membrane of great delicacy may be separated from it, and turned down in folds over the choroïd, presenting the most beautiful specimen of a delicate tissue the human body affords. If a small opening be made in it, and the blunt end of a probe introduced beneath, it may be separated throughout, without being turned down, remaining loose over the retina,—besides being connected with the retina, I find that the membrane is also attached to the choroid coat by a fine cellular tissue and vessels; but its connection with the retina is stronger, and it generally remains attached to that membrane, though small portions are sometimes pulled off with that membrane." Such is the description given of it by its discoverer. By a further reference to the paper, I find, that he expresses himself satisfied with the

fact of its being a single membrane, one fold of a delicate tissue, which concentric with the choroid, is intermediate between it and the retina, to both of which it is stated to be connected, apparently by fine cellular tissue and vessels; because, says the author, " my observations lead me to conclude, that wherever different parts of the eye are in contact, they are connected to each other by cellular tissue, and consequently by vessels."

At the commencement of this paper we find that the texture in question is a perfect membrane " apparently of the same class as that which lines serous cavities:" further on, however, we meet with the following paragraph:—" If the retina be merely in contact with the vitreous humours, we argue by analogy, that a serous membrane exists both on its external and internal surfaces. Yet this is not the fact. In the eye a distinction of parts was necessary, but to accomplish this, a serous membrane was not required; it is only demanded, where great precision was indispensable, as in the head, thorax, or abdomen. *A single membrane, with the interposition of cellular substance, answers the purpose here.*"

From the whole of this paragraph, and still more particularly from the last sentence, it is clear, that Dr. Jacob does not assert the identity of this membrane with serous tissues in general, although some confusion may arise from his likening it to the lining membrane of serous cavities. It is also evident, that the discoverer believed it to be a single membrane. From observations made on the human eye, in connection with other experiments on the eyes of

animals, I am induced to consider it as *a double reflected serous membrane.*

I was first led to take up this opinion in the year 1827, by the accidental observations of a very delicate membrane which lined and was adherent to the entire choroid. Having minutely injected the eye of a sheep, I made a vertical transverse section through the sclerotic, choroid and retina, which last membrane, with Jacob's tunic, properly so called, and the vitreous body, I removed. I then placed the remaining portion of the eye in dilute spirits of wine, intending to preserve it for the exhibition of the tapetum, which in this instance was remarkably beautiful. A few minutes after its immersion, the tapetum lost to a considerable extent its brilliant hue, and I removed it from the glass to wash from its surface some deposit, which I thought might have obscured its polish. In doing this, however, I detached a delicate membrane, minutely filled with injection, and this membrane it was, which on being placed in the spirit, became slightly opaque and produced the effect alluded to; for the tapetum thus denuded, instantly recovered and still retains its brilliancy. I immediately suspected this to be the long disputed membrane of Ruysch, the discovery of which he described as occurring nearly after the same manner. "Sequiter nunc tunica 5ta Ruyschiana, a me dicta, hæc choroideæ tam firmiter connata est, ut vulgari sectione anatomicâ in oculos haud incurret. Artificiosè infarseram choroideæ tunicæ arterias, quas cum suspensâ manu tractarem, recedebat tunicæ Ruyschianæ exigua portio choroideâ.

Hoc à me viso, suspicari cœpi, annon choroidea tunica esset gemina, et artificio quodam in duas lamellas separabilis. Hoc ex voto bis successit, et portionem satis magnam choroideâ separabam, hâc, quam æquè bene ac per choroideam, observabam arterias, peculiares diverso reptatu reptantes, esse dispersas."

By reference to fig. 6, Plate III. this shred of membrane, which I detached from the choroid of a sheep, will be seen represented hanging reflected from the tapetum: it has been found, however, extremely difficult to paint the very delicate nature of its texture, but in the preparation itself, we are able to trace this membrane not only on the surface of the iridescent portion of the choroid, but also over that part blackened by the pigment, which is secreted behind it. This last circumstance, it should be observed, does not at all agree with Ruysch's description, and induces me to consider it as a separate and distinct tissue, leaving the identity of that celebrated anatomist's own membrane, in the same doubtful state, in which reiterated discussions have involved it. The passage in the "Thesaurus," which seems to shew, that what Ruysch considered as his discovery is only the arterial net-work which secretes the pigment, and not this peculiar tissue, is thus distinctly worded:—"Notandum interim hasce artereolas haud esse visibiles, *nisi pigmemtum pullum, quo obsita est tunica Ruyschiana, sit ablatum.*"

In a recent eye, if the point of the finger, previously moistened, be lightly drawn over the surface of the choroid, it will not be found stained with the pigment, nor will this colouring matter, if placed in

water a few hours after death, detach and diffuse itself in the fluid. When, however, the eye becomes somewhat stale, the black pigment falls away in shreds of various sizes, shewing its adhesion to a membrane of some nature or another. If decomposition is still further advanced, this delicate membrane is destroyed, and the pigment now mixes with the water, like any other colouring matter so diffused. Again, if the choroid be removed from the retina, it will be found that this last membrane, in a great majority of instances, is wholly unstained by the pigment; a result which Dr. Jacob explains by asserting that the pigment, being in fact secreted behind his membrane, prevents the nervous expansion being stained by this matter. This, however, is by no means a satisfactory explanation, because as Jacob's membrane, properly so called, detaches in close adhesion to the retina, and as its external surface is, according to this author's account, in contact with the pigment, whence comes it, that it is itself unstained?

The extreme softness of Jacob's membrane, and the great tenuity of its choroidal reflection, make it a matter of much difficulty to exhibit both laminæ in the same preparation; or in other words, to exhibit them both as reflecting portions of one and the same structure, forming a closed sac analogous to other serous membranes. I have, however, in my possession a preparation, which does most distinctly shew the double portions of this membrane; one lining the choroid, the other reflected over the pulpy structure of the retina. The three membranes are

here seen perfectly distinct,—the retina proper, hanging from the optic nerve, the Jacob's membrane concentric to it, and the reflected portion in its proper situation in close contact with the choroid. The drawing at fig. 8, Plate III, represents this preparation taken from the eye of a fish.

There is nothing in this idea abhorrent from physiological laws, nor is there any thing peculiar in a secreting surface being covered with a membrane of an entirely different character; we have an example of this in the mucous surface of the mouth, the œsophagus, and part of the stomach, where the cuticle is in close contact with the secreting membrane. There seems, on the contrary, to be a necessity for a structure of some kind or another, in order to prevent the black pigment from being detached in the varied movements of the eye, and staining, or otherwise injuring the retina. That this effect is not produced by Jacob's membrane is clear, as I think, by our never finding it coloured, though I have invariably found it to be the case at the external choroidal reflection. Moreover, were this membrane single and of a cellular nature, it is more than probable, we should find the pigment transude it, as happens on the outer surface of the choroid.

From the preceding observations, I am induced to believe, that the following description will give the true appearance and relative position of the membrane in question.

At the point of entry of the optic nerve this delicate tissue first commences; it proceeds concentric with, lines, and is attached to the internal

surface of the choroid, as far as the ciliary circle, and " ora serrata;" thence doubling on itself, it is reflected upon the outer surface of the retina, to which it is loosely adherent, forming that exquisite structure first observed and described by Dr. Jacob: in this way it proceeds back to the optic nerve, where it is again continuous with the portion lining the choroid. The latter portion, or the choroidal reflection, wheresoever it comes in contact with the pigment, is stained by it, though it does not allow the colouring matter to transude. Thus, instead of its being a single layer, I think we are enabled to establish, that it is a double and reflected tissue, forming a closed sac, and presenting the peculiarities, anatomical and physiological, common to all such membranes as line serous cavities.

Certain morbid conditions of the eye would seem to point out the existence of a serous membrane at this part, and of these the most remarkable is a peculiar form of " gutta serena," mentioned by Mr. Ware and others, who, in several instances after death, have observed a fluid effused between the choroid and retina. The former gentleman, by puncturing the sclerotic and choroid in some cases, gave immediate relief by removing the pressure on the retina produced by this morbid accumulation. In some rare instances the retina has been found ossified; and Meckel is of opinion, that Jacob's membrane is the seat of this affection. Ossification of serous textures does not unfrequently occur in other parts of the body; as for instance in the pleura costalis, in the pericardium, on the peritoneal surface

of the spleen, &c. It is also sometimes observed on the arachnoid surface of the dura mater. I know of no well authenticated instance, in which the medullary matter of the brain has been converted into bone, although I believe a rare case of ossified brain has been somewhere recorded.

A disease which in its early stage bears some resemblance to fungus in the eye, presents a confirmation of the existence of this serous tissue: hitherto these cases have been described as effusions of lymph from the internal surface of the choroid; is it not more probable that such effusions have arisen by secretion from a serous surface?

In one instance, I have seen an adhesion of the retina to the choroid (in the eye of an ox), rendering separation impossible without tearing the former tunic.

It will be seen by the foregoing paragraphs, that the choroidal portion of what I presume to belong to Jacob's membrane, somewhat resembles the description of a "new membrane of the eye," mentioned in the Report of the British Association for the Advancement of Science (vol. I.), as the discovery of Mr. Fielding, of Hull. I think, however, looking somewhat closely to the subject, that either Mr. Fielding has misnamed this membrane, or that it is but a portion of the tapetum itself, which has been the subject of his investigation. In the first place, the tapetum cannot mean the pigment itself; and, as Sir Charles Bell expressly states, the term is applied to the villous or vascular surface of the choroid, or in fact to what Ruysch describes as his tunic. I confess, however, that I cannot agree in

the existence of the tapetum in the human eye, as by this phrase I understand the brilliant and variously coloured membrane, which forms part of the choroid in many animals. Although I cannot explain upon what the colours depend, any more than I can on what depends the variety of hue in the iris, yet for many reasons, I do not believe it to consist in a matter secreted analagous to the pigment; for in the eyes of many animals, we find the black pigment adhering to portions of the coloured tapetum itself, while other parts of the same membrane retain their splendour and iridescent appearance.

Mr. Fielding in one part of his Pamphlet (published at Hull), states that the pigment is found between the inner surface of the choroid and the "new membrane," and yet that this membrane is divisible into three laminæ at least. The layer, which I have described, holds certainly the same relative position; but not only is it not divisible into laminæ at all, but, owing to its extreme tenuity, becomes exceedingly difficult to detach except in very minute shreds. Again, Mr. Fielding gives to this membrane the name of "versicolor," indicative of its brilliant colours, varying in different animals from the greenish-blue, golden, or Isabella colours. Now the membrane, which I believe to be part of Jacob's tunic, is perfectly colourless, and pellucid, *appearing black* in the human subject from the adhesion of the pigment to its choroidal periphery. Mr. Fielding, with a degree of pleasantry, scarcely in accordance with the severity of language required in all scien-

tific discussions, while remarking that it has been said, Jacob's membrane is sufficient to prevent the retina from being stained by the pigment, observes, "Indeed, Jacob's membrane is a most convenient membrane imaginable * * * * *. In fact, if there be such a part as I am describing, which we find in every eye (though some boldly deny the evidence of their own senses), it *must* be Jacob's membrane A transparent colourless substance, and a semi-opaque brilliantly coloured one, present exactly the same appearance, and must be the same thing!—and therefore, black and white are identical." This, however, brings us to the question of fact. In the human eye, there is no membrana versicolor, for no semi-opaque brilliantly coloured membrane has ever been seen in the posterior part of the eye, although Mr. Fielding thinks "it highly probable this may exist in some instances, though not generally." From all the facts adduced, therefore, I cannot bring myself to believe that the "membrana versicolor" is any thing more than one of those artificial separations, which some of the older anatomists, among whom we find Morgagni, have asserted to be possible in the choroid of certain of the inferior animals.

In the preceding section, we have traced the different investments, that form the boundaries of the eyeball, filled as it is by the various fluids, that will next come under our consideration.

Certain observations have been made respecting the choroid and retina, differing, I am aware, from established opinions on these subjects. An unusual course, too, has been adopted in the description I have presumed to offer, in relation to the optic nerve and its cerebral communications. On these heads, I have to beg an indulgent consideration, as from the extreme delicacy of their several textures, and the minuteness of their organization, the most practised anatomists may be led astray respecting the appearances, which, under manipulation, these structures do actually present.

I have allowed myself to say little on the subject of microscopical investigations, because I am exceedingly distrustful of the results produced by high magnifying powers. In proportion as we increase the powers of our lenses, in like proportion do we diminish the area of the object view, and consequently lose in accuracy and distinctness of outline. Thus with the doublet of Dr. Wollaston, though highly valuing the instrument for general purposes, I have had occasion to be much disappointed with the results, in the investigation of the more minute structures of the eye.

I offer these observations, under a due sense of the circumstances by which the subject is surrounded; conscious as I am, how much of address and delicate management is required in the application of magnifying instruments of every variety of kind and power. On the other hand, I am supported by the concurrent testimony of the very best authorities on the subject, in fixing our anatomical

conclusions regarding the disposition and true nature of the various tissues, in the accordance of pathological observation and analogical physiology, with such as the unassisted eye is able to discover. Thus failing to detect the *villous surface* of the iris, as maintained by Zinn, though aided by the very same means which he describes, the simple observation of the phenomena presented by iritis, and inflammation of the aqueous membrane, will be found sufficient to assign to it a serous covering, the brilliant polish of whose surface excites our surprise, how so accurate an observer should have assigned to it so different a disposition; the combined analogy of physiology and pathology, moreover points out, I apprehend most satisfactorily, the essential muscularity of this same tissue, the iris.

I have been induced to adopt a similar train of reasoning to justify my dissent from the opinion of Dr. Jacob, respecting the actual nature of the membrane, for the discovery of which he is so deservedly celebrated; and, finally, for the purpose of vindicating the course I have pursued, in departing from the established method of tracing the optic nerve.

In the next section we shall proceed to consider a distinct, and different class of structures, commonly called "The Humours of the Eye."

SECTION II.

The Humours of the Eye.

The remarkable structures that next present themselves for consideration, differ greatly from the membranous investments with which we have hitherto been occupied; possessing especial peculiarities in reference to form, function, and arrangement, they require the strictest separation, and individual decription.

They are perfectly and beautifully transparent; are respectively, more or less fluid in their composition; serve equally to distend and give shape to the globe of the eye; whilst each, in its own individual degree, refracts and modifies the rays of light, before they reach and make impressions on the retina.

These bodies have uniformly been called "The Humours of the Eye:" I am, however, opposed to a designation, originating in an error respecting their nature and function, and conveying no exact or definite impression of their real properties. However imperfect at the present period, our knowledge of their minute organization and vitality may be, yet the professors of mathematical and optical science have observed, and sufficiently determined their forms, dimensions, and relations with other parts of the eye.

The rays of light having passed through the transparent cornea immediately enter the anterior and most fluid of these three bodies, under a certain degree of refraction; this refraction is increased and modified by the next, the central and semi-solid lens, further aided by the vitreous body, the last and most posterior of all. Without therefore, at the present moment, going more minutely into their respective modifications and powers, we will accumulate the entire class, and venture to exhibit them under the simple appellation, derived from their certain and demonstrable function, of "refractive or dioptric media."

The refractive media are three in number, situated in the interior of the globe of the eye, and surrounded by the membranes already described. In the tables presented in the preliminary observations, are arranged under separate heads, the vitreous, the lenticular, and the aqueous bodies, subdivided according to the several membranes or capsules, by which they are respectively surrounded, as well as in all probability produced or sustained.

For convenience of description we shall begin with the vitreous body, although it be in the inverse order of individual position; and although, it be also that particular structure, wherein is produced the final perfection of the optical phenomena necessary to vision.

The Vitreous Body.

This structure was known to Galen and to Celsus,

and to nearly all the older anatomists, as occupying the posterior part of the eyeball. They compared it to " molten glass." Its extent and its boundaries do not, however, appear to have been precisely ascertained, since according to Vesalius, with certain of his disciples following in his train, it is described as occupying the posterior half of the eye. Referring to the diagram, Plate II. fig. 1. copied from Vesalius, the vitreous body is represented as dividing the hollow sphere into two nearly equal portions, of which the anterior moiety is filled by aqueous fluid. At a subsequent period, Vesalius corrected by Variolus, Columbus, and some others, appears to have acknowledged the error he had committed. Few and meagre are the facts relating to the structure of this part, that have been added since the days in which these great masters flourished; such, however, as they are, due acknowledgment of them will be rendered, in the course of the description in detail, which it is proposed to submit to the consideration of the reader.

The vitreous body is composed of two parts. A fluid having a specific gravity, somewhat greater than that of water; and a membrane that contains and probably secretes the fluid. Both taken together occupy three-fourths of the hollow globe of the eye, situated the most posterior of the three refractive media, surrounded or invested with the several membranes or coats, already described, as sclerotic, choroid, and retina. With this last tunic it is in absolute contact, though not adherent to it.

In form it is spheroidal at its posterior three-

fourths; at its anterior edge it is somewhat flattened, where it is indirectly in relation to the ciliary body and ciliary processes; while in the most central point of its anterior surface, it is hollowed into a cup-like depression for the reception of the lens. The boundaries therefore may be defined, posteriorly, as far as that membrane reaches by the retina; anteriorly, by the canal of Petit, which is between it and the ciliary body and processes, and by the crystalline capsule.

In the adult it is perfectly transparent and void of colour. In the new-born fœtus it has a rosy hue, attributed by Petit, to a sort of inflammatory action or congestive state of blood-vessels, occasioned by the position of the head in utero, in combination with the mechanical pressure which this part undergoes in parturition. This theory, I need hardly say, is erroneous; it is at once disproved, by the examination of the state of parts in the fœtus of a woman dying in the earlier months of pregnancy.

In general appearance, the vitreous body resembles a mass of colourless jelly, trembling when raised; or white of egg, for it communicates a somewhat albuminous or saponaceous sensation to the touch; or to molten glass, whence its present name. Its specific gravity in relation to water is, as 1000.9, to 1000; its refractive power is, 1.3394. In its chemical analysis, it furnishes gelatine, albumen, and hydro-chlorate of soda,—this is according to Chenevix. Berzelius also has furnished us with a tabular analysis of this fluid.

Water	98.40
Albumen	0.16
Muriates and lactates	1.42
Soda with animal matter soluble in water	0.02
	100

The vitreous fluid is not secreted into a general cavity, but is contained in minute cells, very difficult to demonstrate on account of their exquisite transparency. This circumstance naturally leads us to a special consideration of the membrane by which these are severally formed, and which also gives a general covering to the whole.

The *Hyaloid membrane,* so called from the Greek word ὑαλος, signifying glass, surrounds the vitreous body, and gives to it the particular form already described. It is not, however, a simple bag containing in one general cavity the fluid it probably secretes, but rather a congeries of minute cells formed by a number of extremely delicate prolongations from its own texture, which by a determinate arrangement, though at the same time by an intimate interlacement with each other, eventually communicate more or less freely. The cellular character of this structure seems first to have attracted the notice of Riolan; and came in after time, to be asserted by Petit and Morgagni, and especially by Desmours, by whom it was elaborately examined and explained.

The last named anatomist, in some experiments made on eyes previously frozen, endeavoured to discover the exact arrangement and configuration of the cells, of which the vitreous body is composed. Thus he observes, that the fragments of ice which represent these vesicles, are of larger size at the periphery or circumference of the vitreous body, and that they gradually diminish as they approach the central portion and advance towards the lens. The most external of the cells are two, three, or even four lines in length, and something less in breadth; their convex surfaces are placed externally, whilst the opposite or concave ones are towards the centre and lenticular body. From this arrangement we are entitled to conclude, that the vitreous fluid is retained within its cells, in a manner similar to that (to use a familiar comparison) in which the juice of an orange is contained within the cells of its pulp.

If the vitreous body be immersed in a strong solution of caustic potash, it acquires an opaline tint; the membrane shewing a slight opacity, while the fluid is but little changed: similar results are produced by mineral acids, and rectified spirit of wine. In this way the cellular character of the vitreous body, which, by reason of its perfect transparency was previously invisible, may be most satisfactorily displayed, and the cause of its jelly-like appearance made manifest. Again, the cellularity of the structure of the part in question may be still further exemplified by making a slight puncture into its exterior investment, when a small hernia-like protusion will present, being the fluid

portion of the vitreous body enclosed in its membraneous sacs.

The communication of these cells with each other, may also be demonstrated by a similar puncture, when, gradually, the fluid will escape from the general structure, draining away, and leaving nothing but a few shreds of fine membrane behind. The proportion which the fluid bears to the membrane in which it is contained, is very large. In a specimen under observation, an entire vitreous body, weighing 103 grains, yielded somewhat more than 100 grains of fluid.

It has been shewn, that the vitreous body is in close contact with the retina, but to which it has no point of adhesion unless by a branch of the central artery of the retina, that perforates the optic nerve and subsequently the vitreous body. Yet Bichat mentions a fluid to be found between the hyaloid membrane and the retina, and asks the question, whether this fluid be naturally separated, or, whether it be a mere *post mortem* transudation? To the latter opinion, he appears, not without reason to incline. By a note of the French Translators of Meckel's Anatomy, page 241, vol. III. we find, that a Neapolitan Anatomist of the name of F. Martegiani, has described an empty space between the retina and the vitreous body, the centre of which is occupied by the central artery of the former structure: this space he has called in honour of his father, "Arca Martegiani." The Translators add, that Jules Cloquet admits the existence of such a space, and further, proposes to designate it the

"hyaloid canal." The following quotation from H. Cloquet, (Paris, 1822) does not appear to authorize such a conclusion. "Au niveau de l'entrée du nerf optique dans l'œil, la membrane hyaloïde se réfléchit sur elle même pour former un canal, qui traverse directement d'arrière en avant le corps vitrè." Now, I suspect, that this canal only refers to the tract of the artery that traverses the vitreous body in order to gain the capsule of the lens, and has no relation to that described by Martegiani, which, I confess, I have never been able to observe.

Vascularity of the vitreous body.—In the adult eye, no blood-vessels are perceptible: our most successful injections have totally failed to give colour, even in the slightest degree, to this structure. In the fœtal eye, however, a minute artery conveying red blood may be observed. This artery traverses the vitreous body from behind forwards, beginning to appear at the point where the optic nerve enters the globe; and terminating, by distributing a number of delicate branches over the posterior surface of the crystalline capsule. This is the vessel which traverses what I believe M. Cloquet proposes to call the hyaloid canal, and is given off from the arteria centralis retinæ. I have never seen any branches springing from the trunk in its passage through the vitreous body; but it is hardly to be doubted that some extremely minute, serous, and exhalent vessels do supply the hyaloid membrane, forming the cells mentioned in the account of this structure. In some rare instances a few fine vessels may be traced, passing off from the anterior branches of the arteries

of the retina, to the external portion of this tunic, near to the canal of Petit.

The morbid changes, that are occasionally observed in the vitreous body, incontrovertibly establish the existence of vessels both secreting and absorbent. In certain forms of disease, the fluid of this peculiar structure is greatly increased. At other times, the texture of the entire globe becomes soft, and the quantity of fluid is diminished. The cellular structure, also, at times is apparently absorbed or destroyed, as in those cases *where the vitreous humour is said to be fluid*,—an expression, as may be collected from the anatomical description of the part already given, which is a mere manner or form of speech, since the fluid, that flows from the cells, is not more dense in health, than that which escapes, in the operation for cataract for instance, when this morbid change, or the so called "fluidity of the vitreous humour" has taken place. The truth is, that in this form of disease of the vitreous body, the cells being either broken down or absorbed, the fluid makes its escape, when the cataract is extracted, in increased quantities, and destitute of that viscid appearance and character which has been described as dependant on the cellular nature of that body.

In the disease called "Glaucoma," the vitreous body assumes a yellowish-green, or opaline tint, and loses a portion, more or less according to circumstances, of its transparency: a result, perhaps, of chronic inflammation of the cells, inducing thickening or opacity as in similar conditions of serous membranes; and in which, also, the natural and

healthy transparency of the secreted fluid becomes changed.*

Nerves have never been traced into the vitreous body, which seems altogether devoid of sensibility.

It is usual in this place to describe that elegant structure which has received the name of the canal of Petit; as, however, the theories of its formation are exceedingly various, and as they involve the mention of parts not yet described, I defer the subject until after the detail of the anatomy of the crystalline lens, and its capsule.

The Crystalline Lens.

The crystalline lens, whether considered in relation to its organization, or to its physical properties, is among the most remarkable of the structures of the eye.

Like several other of the constituent tissues of the organ of vision, its precise figure, position and functions, remained long unascertained. Even at the present day, the actual structure of the lens is less susceptible of distinct and rigorous demonstration, than most other parts of the animal economy; its real nature is consequently and proportionably little known.

* Since the above was written, I have, through the kindness of Sir A. Cooper, seen distinct vessels filled with red injection, which were distributed to the membrane of the cells, previous to the branches being given off by the central artery to the capsule of the lens.

True it is, that experiment, and the known laws of physical optics, have concurred to prove that it possesses all the properties of a lens in the highest possible degree of perfection; beyond this point, however, almost the whole subject continues matter of mere speculation: and it still remains to be determined, whether the crystalline body be actually in possession of any power, inherent in itself, of controlling and modifying the focal relations of the eye; or by what other means, if any, the adjustment of the organ of sight to vision at various distances is effected. Certainly there is no parallel texture in the human frame, not even the vitreous body, by comparison with which in regard to function, nutrition, or general structure, we are enabled to reason even analogically on the subject. Of course the present investigation is attended with many and peculiar difficulties.

The system of the crystalline body may be divided, for the sake of perspicuity, into three heads of description,—the lens properly so called, its capsule, and the ciliary zone with its canal of Petit. This latter structure has given much trouble to anatomists as to the order in which it should be placed, owing doubtless to the differences of opinion which exist relative to its formation and function: from its peculiar position, however, and its connection with the capsule of the lens, we shall beg to refer it to the system of the lens, and take it accordingly in the above-mentioned series.

The Structure of the Lens.

This part was by Galen and Rufus Ephesius referred to the class of humours, and from its figure denominated the lenticular; the adjunct of crystalline is equally referable to the transparency which distinguishes both the lens and its capsule. In its texture it is a semi-solid body, and is situated at the anterior cup-like depression of the vitreous body. It is surrounded by the zonula ciliaris, which adheres to the circumference of its capsule. Placed almost immediately behind the iris, and opposite to the centre of the pupil, the lens necessarily inclines slightly towards the inner or nasal side of the axis of the eye.

It appears that Galen, and the more ancient anatomists, were unacquainted with its exact form, since Theophilus, in his Treatise "de Humani Corporis Fabricâ," was the first observer who pointed out the greater convexity of its posterior surface. Vesalius, as may be seen by his drawings, makes both surfaces equally convex, and places it, also most inaccurately, in the very centre of the long axis of the globe. Brisseau, even more erroneously, describes the anterior surface as possessing the greater convexity. According, however, to the very ingenious experiments of Petit, in the Memoirs of the French Academy of the year 1730, the anterior surface of the lens may be considered as the segment of a sphere varying in its diameter, according to the individual subject, from six to nine lines; while the diameter of the sphere, of which the posterior surface

is the segment, varies from four and a half to five and a half lines. The mean between the two, both as regards the anterior and posterior surfaces, may be correctly taken as the general admeasurement of the adult crystalline lens. Kepler, with mathematical accuracy, compares the anterior segment to a portion of a spheroid, the posterior to a hyperbolic cone. *The axis* of the lens is the line drawn from the middle of the anterior convexity to the middle of the posterior, this line being drawn accurately through the centre of the lens. The axis does not, however, correspond with the axis of the eye, but inclines, as being opposite the centre of the pupil, towards the nasal side; it measures one and three quarter lines. *The diameter,* is the line drawn from any point of the circumference to the similar opposite point, dividing the lens into an anterior and posterior segment, or into a superior and inferior half; its measurement is three and a half lines. Hence it follows that the crystalline body is composed of two plano-convex lenses, applied against each other at their flat surfaces; or perhaps, rather as a double convex lens, the greater convexity of which is placed at its posterior surface. The circumference is circular, though by some stated to be slightly elliptical.

In an adult subject, the lens is perfectly colourless, and transparent; immersed, however, in boiling water, spirit of wine, and certain acids, it instantly becomes opaque,—a similar result obtains, from submitting it to a freezing mixture; but in the latter case, it readily recovers its primitive transparency

under the operation of a higher temperature, and when, in consequence, it becomes thawed. After death, and when the body has lost its heat, the lens contracts a slight opacity, which according to Zinn, on the authority of Petit, disappears on being brought near a fire, or when warmed in the hand.

Immersion of the lens in spirit of wine greatly facilitates the investigation of its intimate structure, not only by rendering it opaque, but also by hardening its texture; for in its natural state, the lens is not equally solid in every part, being much softer at its circumference than at its centre: in fact, the nucleus alone approaches to the state of a semi-solid body, the remaining portion uniformly decreasing in firmness as it approaches the circumference, where it becomes almost altogether fluid.

In regard to structure generally, the lens is composed of several concentric laminæ, lying one upon the other, in a manner similar to the arrangement of the several scales or coats observed in the bulb of an onion.

In order to ascertain with equal facility and precision, the more intimate structure and arrangement of the constituent parts of the crystalline lens, an eye should be selected that has been macerated during a few days in dilute spirit of wine; by which process, its surface will be generally observed to be radiated in a stellated form, from the centre to the circumference, by three, six, or nine lines: and when taken between the fingers and pressed with a slight degree of force, it most frequently separates into several equal portions corresponding to these lines.

Each of these fractions, like the aggregate of the whole, is composed of several concentric lamellæ; consisting of a number of minute threads or fibres, running parallel with each other, in an exact and determinate manner, to form the various lamellæ already mentioned.

This disposition of parts is indubitable, although, owing to the softness of the texture of the more external portions in the human eye, it is any thing but easily or distinctly displayed. The case, however, is very different in the lower animals, especially in the tribe of fishes, in which the most unpractised hand will encounter no difficulty in demonstrating the organization asserted.

Meckel, in his "Manuel d'Anatomie," says, that the tissue of the lens is fibrous and laminated; that interposed between the lamellæ may be observed a quantity of diaphanous fluid, in greatest abundance nearest to the circumference; at the surface or towards the periphery of the lens, the lamellæ are considerably thicker; and the fibrous structure is more easily traced, and more distinctly recognised towards the circumference.

A muscular theory of the crystalline lens has been asserted by various eminent authorities, deriving their arguments principally from the fibrous structure first described. The microscopical observations of the celebrated Leuwenhöeck tend doubtless to the same point. The better to estimate the weight and value of this hypothesis, by which is sought to be explained the internal adjustment of the focal powers of the eye, it is deemed expedient to refer

in a summary manner, to the arrangement and structure of the lens, as given by that most accurate and indefatigable of observers.

Leuwenhöeck believed that the crystalline lens was composed of spherical laminæ, lying within and concentric to each other; the number of these, reckoning from the circumference to the centre, he computed at about two thousand: each of these laminæ consists of a single thread or fibre, which passing from before backwards, without crossing or decussation, meets with others at several centres. These centres vary in number in different animals. A similar disposition of parts, somewhat extended, has been asserted by Dr. Thomas Young, the distinguished author of "Lectures on Natural Philosophy," who, in a paper read before the Royal Society in the year 1793, gives the following description of the structure of the crystalline body in the eye of an ox:—"The crystalline lens of the ox is an orbicular, convex, transparent body, composed of a considerable number of similar coats, of which the exterior closely adhere to the interior. Each of these coats consists of six series of fibres, intermixed with a gelatinous substance, and attached to six lines, which have somewhat of a membranous appearance. Three of these lines or tendons are anterior, three posterior; their length is about two-thirds of the semi-diameter of the coat; their arrangement is that of three equal and equidistant rays, meeting on the axis of the crystalline. One of the anterior is directed towards the outer angle of the eye, and one of the posterior towards the inner

angle, so that the posterior are placed opposite to the middle of the interstices of the anterior; and planes passing through each of the six, and through the axis, would mark on either surface, six regular equidistant rays. The fibres arise from both sides of each line; they diverge till they reach the greatest circumference of the coat, and having passed it, they again converge, till they are attached respectively to the sides of the nearest lines of the opposite surface. The anterior or posterior portion of the six viewed together, exhibits the appearance of three penniformi-radiated muscles. The anterior lines of attachment of all the coats are situated in the same planes, and the posterior ones in the continuations of these planes beyond the axis. Such an arrangement of fibres *can be accounted for in no other supposition than that of muscularity*. This mass is enclosed in a strong membranous capsule, to which it is loosely connected by minute vessels and nerves, and the connection is more observable near its greatest circumference." Such is the explanation of Dr. T. Young of the structure of the lens of an ox, and to which in the same paper he states his belief, that the human lens bears an almost perfect resemblance. In a subsequent paper, however, read also before the Royal Society in the year 1800, the opinions of this eminent person seem to have undergone some change; inasmuch as he conceives the number of the radiations to be much more numerous in the human lens, amounting to ten. Dr. Young also observes, that he has laboured with the utmost degree of perseverance, though unsuccessfully, to trace nerves into the body

of the lens. Notwithstanding this failure, he fully announces his conviction of their existence.

There can be but little doubt that the general views of the composition of this curious structure, as detailed by Leuwenhöeck and Young, are correct as far as the laminated and fibrous arrangement is concerned; it is difficult, however, to bring the mind to admit the refinement of penniform muscles, and transparent colourless tendons necessary to the developement of an internal change of figure in the lens itself, as the means of adapting the eye to vision at various distances. It may be objected to this inferential conclusion respecting muscular structure and function (and most fatally too for the theory), that the lenses of fishes are perfectly spherical, and incapable therefore of changing their figure by such an action as that described by Young, in other words, by assuming a more convex form; whilst both the laminated and the fibrous or rather thread-like composition is precisely similar to that of the human lens, with the exception that the texture of the former is considerably more dense than that of the latter. In point of fact, the nucleus of the lens of a fish's eye, though both laminated and fibriform, is still so hard as scarcely to be divided by a knife.

Thus the apparent structure of the lens consists of a series of transparent threads, coiled up in a peculiar and determinate arrangement from the centre to the circumference, wound in a stellated form, radiating towards each of the poles of the lens, and disposed in separate lamellæ, to use a familiar comparison, very similar to a ball of cotton thread tightly

compacted in the centre, and wound gradually more loosely as the thread approaches the circumference: the fibres, of which the lens is composed, to use the phrase of Sir E. Home, resemble the delicate threads of spun glass.

The next question which presses on our attention, is, of what nature are these fibres, and what is their intimate organization? Ruysch and Boerhaave considered them as formed of vessels. This, I need hardly say, is not borne out by any demonstrative proof, nor can we allow more credit to the assertion that they consist of a system of tubes filled with a transparent fluid.

The opinion of Zinn, and corroborated by Morgagni, appears to me the most probable, which shews it to consist of a fluid matter of a peculiar nature, with an interposed and regularly arranged cellular structure, or to use the words of that accurate observer, "Ipsam autem illam aquulam contineri in intervallis cellulositatis subtilissimæ, experimentis meis nixus crediderim." "Membranulas in lente vidit Morgagnius." Berzelius also believed that the lens was composed of membranous cells similar in structure, though differently arranged, to those of the vitreous body.

The density of the lens at its centre is, as Porterfield says, equal to hardened suet, but externally its consistence is about the same with that of thick jelly. This softer state of the more exterior portion of the lens is apparently owing to the secretion of a transparent fluid, observed between its constituent lamellæ, similar in appearance and general character

to that matter which will come to be described under the name of the "liquor Morgagni."

Resulting from his previous investigations, Dr. Young announced the discovery of a substance, not previously observed, which he says, "fills up the marginal part of the capsule of the crystalline, in the form of a thin zone, and makes a slight elevation visible even through the capsule: it consists of coarser fibres than the lens, but in a direction nearly similar; they are often intermixed with small globules. * * * * Its use is uncertain, but it may probably secrete the liquid of the crystalline; and it as much deserves the name of a gland, as the greater part of the substances usually so denominated." The author does not positively affirm, that this tissue exists in the human eye, but he infers it, partly from anatomical observations, and in part from the analogy which exists between the structure of the human lens and the lenses of other animals.

Berzelius, who has with so great labour and not less accuracy investigated the chemical composition of the various fluids and solids of the human body, presents the following analysis of the crystalline lens:

Water	58·0
Peculiar matter	35·9
Hydro-chlorates, lactates, and animal matter soluble in alcohol .	2·4
Animal matter only soluble in water, and phosphates	1·3
Insoluble membranous residue . .	2·4
	100·0

According to Chenevix, the lens contains a considerable quantity both of gelatine and albumen; and when it has undergone the action of fire and has been reduced to ashes, we find distinct traces of iron.

The result of such an analysis invalidates, nay, destroys the theory, that assumes a muscular structure to the lens; at least, if such a structure and function depend upon an organization similar to what occurs in the moving powers of our limbs; because in this body, we find not the slightest trace of fibrine, the essential basis of all muscle in all parts of the animal system.

The Capsule of the Lens.

The crystalline lens is surrounded by a capsule, like itself perfectly colourless and transparent; in shape, also, it exactly corresponds to the body it encloses. It is imperforate and entire; neither does it appear to possess, at its internal surface, any reduplications to connect it with the surface of the lens. Externally, it is embedded in the cup-like depression formed at the front of the vitreous body, where it is adherent by a fine cellular tissue to the hyaloid membrane. At its circumference it is connected and fixed, by firm adhesions, to the radiated membrane of the anterior surface of the canal of Petit; by which arrangement the crystalline lens is kept permanently lodged in the hollow of the vitreous body. Anteriorly it is, as we shall hereafter

see, covered with the membrane of the aqueous fluid: it is much firmer at this point than posteriorly. It is highly elastic, and preserves its form even if immersed in alcohol.

Haller describes the capsule as closely resembling in its tissue the cornea: this observation is more applicable to the lining membrane, or what is more generally called the aqueous membrane, according to the recent observations of Dr. Jacob. Bichat is confirmed, however, in Haller's opinion, by the observation of capsular cataract, which he remarks is to be compared to the specks and opacities of the cornea. This, indeed, is nothing more than the natural result of the deposition of lymph on the surface, or in the interstitial texture of any transparent membrane. We might by a parity of reasoning, compare the crystalline capsule to the pericardial covering of the heart, because the latter shews, sometimes, the opaque results of inflammation. In point of fact, I believe there to be a much greater resemblance between the latter membrane and the crystalline capsule, than between the capsule and the cornea. Kenneday in his "Ophthalmographia," (1713) observes of the lens, "Its coat, I think, being something to it not unlike the pericardium."

Neither acids nor boiling water render it perfectly opaque; but exposed to the action of these agents, its transparency undergoes a marked change, and acquires a hue not unlike mother of pearl.

Liquor Morgagni.—If we puncture the capsule with a fine needle, we observe a small quantity of fluid to escape; this, which is known by the name of

the "liquor Morgagni," was discovered by Steno, in the eye of a fish, and afterwards examined with great care by Petit, and that illustrious anatomist whose name it bears. In quantity it scarcely amounts to a grain, and appears to be situated more towards the anterior than posterior part of the capsule: it seems to be similar to, if not identical with, the fluid that infiltrates the more external laminæ of the lens. Baerens, "de Systemate lentis," (1819) believes that it exists in the form of vapour during life. Whether fluid or vapour, however, its position around the lens, does seem, as it were, to isolate this body, intercepting its direct connection with the capsule, and rendering the fact of an immediate vascular union between these parts more than doubtful. This circumstance naturally leads us to an enquiry respecting the actual nature of its organization, a subject involved in much difficulty, and concerning which great diversity of opinion has heretofore prevailed.

The Organization of the Lens and its Capsule.

As a description of the arteries of the eye will be presented to the reader in a subsequent portion of this work, it may suffice to give a brief account of the means by which blood is supplied to this body and its capsule, and at the same time a short statement of the several opinions entertained by certain writers on this subject.

As the crystalline lens, in the healthy eye of an

adult subject, is perfectly transparent and void of colour, it follows of course that it contains within its substance no vessels carrying the red particles of the blood—and inasmuch as in the earlier periods of the science the art of making anatomical injections was unknown, it is any thing but surprising, that the existence of blood-vessels in this part of the eye, was denied by Galen and the older anatomists. Haller, in his description of the arteries of the eye quotes an Englishman, of the name of Allen Moulin, as the first observer, and in fact the discoverer of these long denied vessels.

Even during a long period afterwards, the art and habit of injections furnished no other results, than the exhibitions of arterial branches, derived from the central artery of the vitreous body, expanded on the posterior surface of the capsule of the lens, together with some small twigs proceeding anteriorly from the ciliary processes. It will be seen from the following passage in Zinn, in how high estimation the most successful injector of any age was held by him, and how slow even Ruysch himself was to admit the presence of blood-vessels in the lens. "Ruyschius quidem vasa lentis olim negaverit, fidus tamen et simplex naturæ scrutator illa admittit, serius in ove sanguine spontè plena reperta, et, ut eo major foret experimento fides, arteriolæ in parte posteriori sibi visæ iconem exhibuit."

The injections of Winslow appear to have been eminently successful, shewing vessels distributed to and entering the very substance of the lens; an im portant fact confirmed by the concurrent testimony

of Albinus and Haller. Senac, also, relates the fact of his having seen an artery distributed through the texture of the crystalline lens in the eye of a horse. Those cases, however, in which the blood-vessels are found actually filled with red blood, or capable of being artificially injected, should rather be considered the results of morbid action, and dilatation of the arteries, than as specimens of healthy and natural organization.

The foregoing authors are of the highest authority in our science, and they unite in asserting the fact of the existence of blood-vessels, not merely in the capsule, but in the very body of the lens itself. On the other side stands conspicuous the antagonist opinion of Bichat, certainly one of the most celebrated physiologists of modern times. In his work entitled "Anatomie Generale," he says, "En a demandé depuis long temps si le crystallin étoit organisé? Beaucoup de recherches ont été faites pour s'en assurer, et il résulte de toutes qu' aucun vaisseau sanguin ne se répand dans la substance crystalline propre, mais seulement que sa capsule en reçoit un ou deux dépendens de l'artère centrale de la rétine." M. Cloquet is not so positive in his expressions relative to this point. "Il paroit probable que les ramifications arterielles se bornent à sa membrane." Meckel delivers himself in accordance with the older authorities already named, and contends, that the arteries ramifying on the capsule of the lens send many very delicate branches to be distributed to the laminæ of which the body of the lens is composed.

Lastly, it is clear, that from many observations

made in cases of disease, vessels, which before have only carried the colourless and transparent part of the blood, are capable of admitting and circulating the red globules. The following passage in Mackenzie's very excellent "Practical Treatise on the Diseases of the Eye," confirms in a beautiful manner this interesting fact. "Posterior to the red vessels seen in the capsule, there appears in some cases a net-work of more delicate vessels which seem to be seated in the lens itself. The larger trunks of this net-work are not always derived from the circumference of the lens, but evidently come, says Professor Walther, from its posterior surface directly forwards, and these divide into branches. The presence of these vessels in the lens he has repeatedly and distinctly observed. He states they present one of the most beautiful phenomena, and that the only things which come near to them, are the finest injections of the choroid, such as those which are in the possession of Soëmmering, and have been represented by him, in his work on the anatomy of the eye."

From all these details it is more than probable, that the lens itself is highly organized, so far as relates to its vascularity. The source, whence these vessels are obtained, will be found in the capsular branches. The posterior are derived from the stem that pierces the vitreous body, and expands at the back of the capsule, anastomosing with the anterior branches, that principally originate from the ciliary processes, and in some rare instances from some small twigs of the artery of the retina, which enter the circumference of the lens.

The veins are, at present, much less distinctly traced than the arteries; in all probability, they pursue a similar course, and accompany them as venæ sociæ.

Nerves have not yet been discovered either in the lens, or its capsule; a similar observation applies to the lymphatic vessels.

The following tables exhibit a few further admeasurements of the size, position, and refractive power of the lens, by Dr. Young, and Petit.

	Inches.
Radius of the anterior surface of the lens	0· 30
Ditto of the posterior surface . .	0· 22
Thickness of lens	0·172
Distance of the anterior surface of the lens from the iris	0· 92
Principal focal distance of lens .	1· 73

Refractive power of the outer coat of the lens	1·3767
Ditto ditto of the centre coat	1·3990
Ditto ditto mean	1·3839

The last table is according to the observations of Sir D. Brewster.

Canal of Petit.

Although we are unacquainted with the use or the organization of the membrane which forms the

canal of Petit, yet I have thought it advisable to follow the plan of Baerens ("Radius Script: Oph: Min:") and class it with the structures more or less connected with the crystalline lens. It seems, indeed, to hold a place, in regard to the internal membranes and dioptric media, somewhat similar to the ciliary circle, in regard to the outer investments of the globe; for, in fact, at this spot are bound together and brought in direct relation to each other, the following structures, namely, the retina, ciliary body and processes, the vitreous and crystalline bodies.

It has been observed, that the retina is in contact with the periphery of the hyaloid membrane, up to the margin of the ciliary body (ora serrata), where the nervous structure ceases; there remains, then, a space between this point and the circumference of the crystalline capsule, which is occupied by the membrane known by the name of "lamina ciliaris," or "zonula Zinnii."

On exposing the vitreous body, with the lens in its true position, around the circumference of the latter a plicated circle may be observed, marked alternately with black and colourless radiating lines corresponding, as it were, with the ciliary processes, against which it is applied. On close examination, a fine but strong membrane may be seen, collected into folds like the plaiting of the wristband of a shirt, entirely surrounding, and attached to the circumference of the capsule of the lens. So soon as we have traced it to this spot, it ceases to be visible in consequence of its close adhesion to the capsule; nor are we in possession of any direct proof, whether

it does, or does not invest this structure. The breadth of the zone in question, corresponding with the iris in front, is somewhat narrower on the nasal side of the eye. On its anterior surface, a series of slight elevations and depressions, placed in alternate order, may be observed. The former are colourless, and transparent; the latter, usually though not invariably, are tinged black by the pigmentum nigrum torn off, or separated from the ciliary processes.

If a small puncture be made through the membrane, close to the circumference of the lens, and a small quantity of air be gently introduced through a fine blowpipe, the whole circle will be immediately elevated, and a canal, entirely encompassing the lens at its circumference, will be demonstrated. This is called after the illustrious author of the discovery, the "canal of Petit;" or, from a supposed resemblance to the chased rim of a circular silver dish, the "canal godronné." When inflated the canal, or its anterior membrane, is forced out into little cells or sacs, and may be compared, not inaptly, to the appearance of an inflated colon, forced into pouches from the resistance afforded by its longitudinal muscular bands. (Zinn.) In the line of the canal, these cells are not distinct, or divided by septa from each other, but are occasioned solely by the state of tension of the radiating fibres, that alternate with them.

In the recent eye, the canal requires this inflation in order to be made apparent, because in this state of the organ the anterior and posterior surfaces are in contact; when, however, it is distended with air,

or wax injection, and cut by a vertical section, its figure will be found irregularly triangular: its base is formed by the posterior edge of the circumference of the lens; its posterior side by the hyaloid membrane, and the anterior by the zonula Zinnii, or lamina ciliaris.

This membrane it is in which the cells, or rather the alternate elevations and sulci, are found; and when examined in conjunction with the retina, its whole outer circumference will be seen to present a beautiful series of scalloped edges, whose convexities are mutually received into the concavities terminating the anterior edge of the retina. These two tissues are not only thus locked in, as it were, but are strongly adherent, probably if not certainly, through the medium of the cellular tissue which supports the blood-vessels of the retina.

On its anterior surface is applied the ciliary body, which commences to be adherent to it at the ora serrata, joining in a way precisely similar to the retina at the edge. A little further on, and nearer to the circumference of the lens, the ciliary processes dip down into and adhere to the sulci we have before remarked; while the elevations of the lamina ciliaris, in like manner, are insinuated between the interstices of these processes, whose extreme points are however free and unattached.

Winslow and Lieutaud believed, that up to the margin of the retina the hyaloid membrane was composed of *two consolidated* laminæ, which still more anteriorly were severed into *two distinct* portions, of which one portion passed behind to the cup-like

cavity into which the lens is received, whilst the other ascends to the circumference of the lens, where it becomes intimately connected with its capsule, surrounding it and giving it an investment anteriorly. Other anatomists, and amongst them several of high authority, argue that the tunica vasculosa retinæ passes more forward than the pulpy layer of this body, and that it advanced to the very margin of the lens in close and intimate connection with its capsule, leaving around its immediate circumference that free space denominated the canal of Petit.

The opinion entertained by Sir C. Bell, differs essentially from either of these conclusions; and impressed as my mind is with the originality and extreme ingenuity of the theory, I cannot doubt that I shall be excused if I quote the very words of that distinguished observer. "I conceive," says Sir C. Bell, "that it is the membrana vasculosa tunicæ retinæ, or membrana vasculosa Ruyschii, which forms the vascular capsule of the lens in the fœtus, and also the canal of Petit in the adult. The crystalline lens has, in the first place, its proper capsule, which surrounds it on all sides: again, the transparent web of membrane that is continued onwards from that part of the retina which has upon it the pulpy and nervous expansion, splits when it approaches the margin of the lens. One lamina goes round behind the lens, and the other passes a little before it, forms an adhesion to the capsule of the lens, and is then reflected off to the points of the ciliary processes and to the membrana pupillaris of the fœtus.

Betwixt these split laminæ of the continued membrane of the retina, the canal which surrounds the lens is formed. The membrana vitrea is simply reflected over the back of the lens, and has no part in forming the Petitian canal. Where the retina advances forwards upon the ciliary processes, it forms an adhesion, beyond which the medullary part is not continued; but the membrana vasculosa passing onwards, as I have described, embraces the lens, and the lamina, which passes behind the lens and before the vitreous humour, receives and conveys the artery of the capsule; on the fore part of the lens, the anterior lamina only touches the capsule of the lens, adheres, and is then reflected off to form the membrana pupillaris."

From the theory of the splitting of the tunica hyaloidea, as supported by Winslow and others, I dissent, because at the identical spot, where this division is said to take place, the lamina ciliaris is denser in its texture, and capable of greater resistance than the consolidated or united layers at any other part, insomuch that the entire vitreous body may be raised and suspended by it; whilst in any other spot, the tunica hyaloidea would be torn by less than half the weight. The same observation applies to the splitting of the tunica vasculosa retinæ, even did I agree in the separate and distinct existence of such a membrane. Notwithstanding, therefore, the ingenuity of the theory of Sir C. Bell, I rather incline to the opinion of the so often quoted Zinn, who supports the existence of a distinct membrane to form this anterior layer of the canal of Petit. "Annon

autem ad veri speciem proprius accedit, ex tenerrimâ tunicâ vitreâ novam hic ortam fuisse membranulam, quam si quis nobis persuadere vellet, tunicæ vitreæ lamellas duas, posterius sibi agglutinatas, anterius à se invicem ad constituendum illum annulum secedere, cum nullibi vel levissimum vestigium duarum lamellarum observari possit, neque ab ullâ arte humanâ in tunicâ vitreâ duas demonstrari posse lamellas, expectari posse videatur?" Zinn, however, believes that the membrane which has been called by his name, passes further than the mere circumference of the capsule, even to the investiture of its whole anterior surface. This also is the opinion of Baerens; who adds a third coat to the same capsule, namely, the membrane of the aqueous humour: this latter, I do indeed believe covers the capsule of the lens; but at the same time I would limit the lamina ciliaris to its marginal circumference.

Amongst other theories even still less probable may be mentioned, that which derives its formation from Jacob's membrane, and the one which gives a muscularity to this pellucid tissue; the latter was supported by Sir E. Home, who described the appearances thus:—"Between these membranous processes (process. ciliares) there are bundles of muscular fibres of $\frac{25}{100}$ of an inch in length, which have not before been described; they originate all round from the capsule of the vitreous humour, pass forward over the edge of the lens, are attached firmly to its capsule, and there terminate as seen in the drawings. They are unconnected with the ciliary processes or iris. In the human eye and that of quadrupeds, they form

bundles with intermediate spaces. In the bird they are nearly one continued layer of muscular fibres." (Croonian Lecture, 1821.) Camper, in his dissertation "de quibusdam oculi partibus," has however asserted the discovery nearly to the same extent, which was completely negatived subsequently by Zinn.

To shew how much at variance authors have been upon this confessedly difficult point, I will subjoin a few of the names of the eminent disputants.

The authors, who support the theory of the formation from the hyaloid membrane, are Morgagni, Petit, Winslow, Maitrejean, St. Yves, Haller, and Cuvier.

Those who derive it from the retina, are Cassebohm, Ferrier, Palucci, and Sir C. Bell.

Those who assert its muscularity, Camper, and Sir E. Home.

Finally, others hold that Jacob's membrane supplies its place. The extreme difference, however, of the two membranes, completely disproves this assertion.

The Aqueous Fluid and its Membrane.

Prior to the time of Galen, only two of the structures called "humours of the eye," were distinctly known, and described. To Galen we are indebted, if not for the actual discovery, at least for the introduction into anatomical science, of the third or aqueous humour, as it was denominated from its resemblance to water.

This fluid occupies all that portion of the cavity of the globe of the eye, which is situated before the crystalline lens. It bathes both the anterior and posterior parts of the iris, filling certain small cavities, called in anatomical language the "chambers of the eye." In a pathological point of view, as well as in reference to certain surgical operations upon the organ of sight, it is essential to mark, in a distinct and decisive manner, the respective limits and the mutual relations of the anterior and posterior chambers, separated as they are from each other by the iris, and communicating only through the pupillary opening of that membrane.

By the older anatomists much variety of opinion seems to have been entertained respecting the absolute and the relative size of these cavities; and as the practical value of the established division, purely artibrary in its nature, depends on a correct understanding of the space which each of them occupies in relation to the other, a short survey of some of the older authorities on the subject will be necessary.

In the engraved representations of the eye by Vesalius and Briggs, it is evident, that by an error in placing the lens in the centre of the globe, the ciliary processes have been removed to the extent of several lines from the posterior surface of the iris, giving as a necessary consequence to the posterior chamber, occupied by the aqueous fluid, an incorrect and disproportionate size. In fact, the anterior space, in the plates referred to, is smaller than the posterior cavity by at least five parts in six—a proportion

which, if reversed, would much more nearly express the truth. Subsequent observations corrected this error, and demonstrated the actual fact; not, however, without much difference of opinion amongst the most celebrated anatomists of the day. Petit, and Haller, and Morgagni agree in the existence of a posterior chamber of considerably smaller dimensions than that exhibited by Vesalius, whilst this cavity is altogether denied by Winslow and Lieutaud. Nor is this discrepancy matter of marvel. Almost all the observations upon this subject were made upon eyes previously frozen, in order to determine by the congelation of the aqueous fluid, the relative space occupied by each of the two chambers. Hence, seeing that the aqueous fluid escapes very rapidly by transudation after death, and that in order to obtain identity of result, the subjects acted upon by each observer ought to have been perfectly and equally fresh, the notable difference of facts remarked. In truth, in all experiments of so delicate a nature as that under consideration, no observation should be commenced, since none can be successfully followed out, but upon eyes removed from the orbit immediately after the death of the body. In conclusion, as the aqueous fluid transudes so much more quickly than the vitreous, the latter will possess a greater relative preponderance in quantity, as well as in expansive power during the act of congelation; whence a forced projection of the vitreous body and crystalline lens, together with eventual obliteration of the space previously occupied by the aqueous fluid. True indeed it is, that this effect is

not invariably produced; yet it occurs most frequently, and has in all probability given rise to the error, into which Winslow and Lieutaud have fallen, respecting the question of the posterior chamber of the eye. If the conclusions of these eminent anatomists were correct, the anterior surface of the iris would be convex, in consequence of its being forced into close contact with the lens; and during every motion of the iris, a certain degree of friction would be produced, materially injurious to parts so fine and so delicate in their textures as this membrane and the capsule of the lens; an effect which has been most simply and beautifully prevented by the interposition of a small quantity of fluid between them, so that the functions of the iris are performed altogether in an aqueous medium.

The shape of the space, which for practical purposes has been subdivided, is thus very distinctly described by an old mathematical anatomist, Christr. Scheiner (Fundam. Optica, London, 1652.) "Aqueus enim, quia corneâ, uveâ, processibus, et araneâ continetur, illorum figuras internas induit: unde anteriore sui portione convexus, secundum corneam, posteriore concavus, secundum crystallini insinuationem, existat oportet, in medio insectus et in collum quasi quoddam strangulatus apparet, crassius aut tenuis, pro majore vel minore uveæ dilatatione, aut coitione."

Thus the posterior chamber is bounded posteriorly by the anterior surface of the capsule of the crystalline lens, and the free points of the ciliary processes; anteriorly it is bounded by the uvea, or

posterior surface of the iris; its circumference is surrounded by the junction of the ciliary processes with the iris. In depth it measures about half a line; in capacity or extent it is equal to about one-tenth part of the anterior chamber, which latter is about three lines in depth, and being situated between the iris and cornea, has obtained its distinctive appellation.

For convenience of description, the aqueous body may be distinguished into the fluid that occupies the posterior and anterior chambers, and the membrane that lines those spaces: bearing in mind, that the aqueous body, like the vitreous, is composed of two parts; *Firstly*, a certainly investing, and probably a secreting membrane; *Secondly*, a contained and secreted fluid.

The Aqueous Fluid.

This fluid, contained within the chambers of the eye, amounts in quantity to from four and a half to six grains, depending in degree on the greater or less convexity of the cornea. Chenevix gives its specific gravity at 1·0003: and in his chemical analysis, asserts the presence of gelatine, albumen and muriate of soda. The following table is given by Berzelius:

Water	98·10
Albumen—a trace	
Muriates and Lactates	1·15
Soda with animal matter soluble in water	0·75
	100· 0

Of its general chemical qualities, the following passage from Henry affords the best explanation. "The aqueous humour," says he, "is a clear transparent fluid, of the specific gravity of 1009 (water taken as the standard at 1000). It has little smell or taste, and scarcely affects blue vegetable colours; by evaporation it leaves a residuum of about eight per cent; boiling occasions a slight coagulation, and tan precipitates both before and after being heated. Nitrate of silver precipitates muriate of silver from it, but no other metallic salt affects it. Hence it may be inferred, that the aqueous humour consists of a large proportion of water, of albumen, gelatine, and several neutral salts." The most remarkable difference between these two celebrated chemists, is in the large per centage of solid residuum, which Henry gives as eight in one hundred; while Berzelius gives only about one and nine-tenths. By a comparison of the tables of the analysis of the aqueous and vitreous fluids, we find their constituents altogether the same, as far as the principles are concerned, and that they only vary in the proportion in which the fluids and solids are blended. The refractive power of this fluid is given by Sir D. Brewster, as 1·3366.

The Aqueous Membrane.

Various are the tissues and internal structures of the eye, that, at different times, have been supposed to be the secreting organs of the aqueous fluid. In

a chapter of Zinn, headed "Natura et Fontes Humois Aquei," we find most of these opinions quoted, and the authors of them named. Thus Nuck, a Dutch anatomist, believed he had discovered a proper source of this secretion in what he denominated aquæducts. He wrote a treatise on this subject, under the title of "Tractatus de ductubus oculorum aquosis," and defended it against some of his cotemporaries in a work denominated, "Defensio ductuum aquosorum." Haller, however, completely disproved this doctrine; and made it manifest, that the two vessels supposed by the Dutch observer to bring the fluid into the aqueous chambers, were, in fact, only the long ciliary arteries that, in chief, form the two vascular circles upon the iris. St. Yves imagined that this aqueous fluid was produced by a kind of transudation or *sweating* through the tunic of the vitreous humour, and even of the crystalline itself. Others of some note attributed its secretion to the arteries of the anterior surface of the iris: while Zinn and Haller suspected the ciliary processes, from their considerable vascularity, to be the proper organ of the secretion of the fluid. Many and cogent arguments may be brought against any and all of these hypotheses: we must therefore look to some other tissue as formed for, and destined peculiarly to this purpose. Let us therefore examine that membrane, at present known to us by the term "aqueous membrane or capsule."

Who the discoverer of this tissue was, does not appear to be distinctly ascertained, although it is generally attributed by English anatomists to Sawrey,

who published an account of "A Newly Discovered Membrane in the Human Eye," in the year 1807 (London.) A hint of its existence was, however, given by B. Duddell at a much earlier period, in a treatise "On the Diseases of the Horny Coat of the Eye," published in London in the year 1729. Jourdan and Breschet, the translators of Meckel's "Manuel d'Anatomie," attribute it to either Demours or Decemet, who appear to have contended for the honour of the discovery, somewhere about the middle of the last century. It has been said, that Zinn was acquainted with the fact prior to the two last-mentioned authors. I confess, however, that after having diligently read that writer's excellent work, so often quoted in these pages, I have not been able to meet with any passage that appears to me to refer to this membrane, but rather on the contrary; for when speaking of the cornea, in connection with which he was most likely to have mentioned it, he says, "Lamina illis interjecta, et cellulosa quædam subtillissima, quà artissimè inter se uniunter, ut extima tamen lamella faciliùs scalpello separari queat interiores autem arctiùs inter se cohereant:" whereas the membrane now called aqueous, and which was till recently supposed to be the interior lamella of the cornea, separates more readily than any of the other layers of that tissue.

By some modern anatomists, the extent of the aqueous membrane has been limited to the concavity or posterior surface of the cornea; by others, it is stated to be traceable upon the anterior face of the iris. It will however be evident, that Zinn, when

speaking of the villous flocculi of this colored curtain, could have had no idea of the aqueous membrane extending over and giving an investment to its surface. This, however, is an opinion very generally admitted at the present day; and the description of Cloquet, up to a certain point, is most undoubtedly correct, when he says, it lines the whole of the anterior chamber, and in the fœtus forms a serous sac, by reason of the existence of the pupillary membrane. The next sentence, "Dans aucun cas elle ne pénètre dans la chambre posterieure," is not so completely borne out by fact.

I believe that the aqueous membrane lines both chambers, or the whole cavity containing the aqueous fluid: that it invests all the tissues found in this compartment of the eye; that exclusive of the fœtal state, it forms one entire closed sac, of a serous character, and capable of secreting the fluid therein contained. Previously, however, to exhibiting the arguments in favour of this hypothesis, the following description is submitted relative to the proposed reflections and attachments of the membrane.

The aqueous membrane, it is assumed, lines the cornea at its concave surface, adherent but not very closely to it; hence it is reflected, at the point of junction between the iris and cornea, upon the former tissue, most intimately attached to its anterior surface, as far as the margin of the pupil; it then passes through this opening, and is connected with the posterior surface of the iris, or uvea, by loose cellular tissue, the pigmentum nigrum so plentifully secreted at this point, being placed between it and

the uvea; lastly, it turns over the extreme points of the ciliary processes upon the circumference of the crystalline capsule, which it covers most intimately at its anterior segment, thus completing the investment of both chambers of the eye.

At the point where the aqueous membrane lines the cornea it is tough, and has been compared by Dr. Jacob of Dublin, to a semi-cartilaginous structure. When reflected upon the iris, it is so exquisitely thin, that it escapes the unassisted eye, and the scalpel of the anatomist, and is only shewn to exist by the very apparent effects of disease. It is little affected by boiling, or immersion in acids. Spirit of wine, however, impairs the brilliancy of the iris, by thickening the aqueous membrane, and troubling its transparency. At this particular point, and while in the anterior chamber generally, some forms of disease demonstrate its existence most perfectly. For instance, in *iritis,* one of the earliest symptoms of this malady is a loss of polish and brilliancy in the iris, followed by a diminished transparency of the posterior surface of the cornea: the anterior chamber frequently becomes changed with soft lymph, not easily to be distinguished from pus, and which has often erroneously been confounded with true *hypopion.* As the inflammation advances, the membrane is seen covered with tubercles of lymph, which in some cases become organized, and destroy vision by adhesions of the iris, terminating in perfect closure of the pupil. Again, if a wound be made through the cornea, and the aqueous fluid escapes, often we find adhesive inflammation set up,

and if the iris comes in contact with the cornea, adhesion immediately ensues. When an ulcer forms on the anterior surface of the cornea, and goes on without controul until it destroys successively each separate lamina, before it absolutely penetrates the anterior chamber a little membrane is observed to be pushed forward into the excavation, convex, and resisting for a long time the ulcerative process: this same little hernia, or vesicle as it appears, is the serous membrane of the anterior chamber.

The same train of observation applies to the demonstration of the membrane in the posterior chamber, as exemplified in cases of synechia posterior, adhesions of the margins of the pupil, opacities of the anterior capsule of the lens, &c.

In order at once and clearly to understand the anatomy of this delicate tissue, it is necessary to anticipate the relation of a structure, called the "membrana pupillaris," which exists naturally only in the fœtal state. Prior to the seventh month of utero-gestation, the iris appears to be an entire and continuous membrane, absolutely dividing the two chambers of the eye. The pupil of the fœtus at that age is filled by a fine vascular tissue, to which the above-mentioned name is applied. Now it is certainly true, that in each chamber or compartment of the eye, even while no communication exists between them, a quantity of fluid, more or less, may be found. This, the aqueous, which we have just described, completely disproves the older theories of its source; for it is clear, that the ciliary processes or uvea could have nothing to do with the existence

of water in the fore part of the eye; nor, vice versa, could the flocculi, as Zinn expresses himself, of the anterior surface of the iris, secrete the fluid found in the posterior chamber. In a memoir by Jules Cloquet, on the membrana pupillaris (Paris, 1818), that author has distinctly made out the fact, that this structure is composed of *two* thin laminæ, between which a considerable number of blood-vessels ramify; and that each chamber forms, as it were, a closed and serous sac: but as the membrane begins to disappear at the seventh month, and is wholly wanting at birth, it seems as if by its absorption in the centre the edges of the two sacs came in contact at the pupillary margin, and by their intimate union converted the two originally distinct chambers into one common cavity: the present nominal division being one of mere anatomical or pathological convenience. Let us refer to plate 4. fig. 1., and trace the delicate layer that lines the concavity of the cornea, upon the colored surface of the iris, and closing the aperture in the centre by its continuity; this space is filled with fluid, and at this period may be called, in strictness, the "anterior chamber."

Posteriorly we see another membrane filling the pupil, loosely connected with the anterior by a delicate arrangement of vessels; it lines the uvea, its reflections may be traced upon the extreme points of the ciliary processes, and continuously to the anterior layer of the capsule of the lens. Another closed sac (the posterior chamber), also containing water, is here discovered, corresponding to that

placed before the iris. Remove those portions of membrane which close the pupil, a process effected by nature a short period prior to birth, and the two spaces become one cavity; and the fine serous tissues that line the anterior and posterior chambers, touching and adhering at the margin of the pupil, henceforward become one and the same continuous membrane. (Vide Plate 4. fig. 2.)

This, probably, is the true nature and disposition of the aqueous capsule, the secreting and absorbing organ of the chambers of the eye. The abundance and rapid production of this fluid when lost by accident, are matters appertaining rather to physiological than purely to anatomical science. The fact, however, sufficiently shews the high, though minute organization of this membrane.

Having now completed the investment of the globe of the eye, as far as our proposed plan of description has allowed, and having detailed the anatomy of the fluid media; it may not be without its use to give in a tabular form, the dimensions and admeasurements of the different portions which complete the structure, as investigated by Petit and Dr. Young.

		Inches.
Length of the optical axes . . .		0·91
Vertical cord of the cornea . . .		0·45
Versed sine of ditto		0·11
Horizontal cord of ditto		0·47
Opening of the pupil seen through ditto	0·27 to	0·13
Distance of the iris from the cornea		0·11

Distance of the iris from the anterior surface of the lens	0·92
Radius of the anterior surface of the lens	0·30
Radius of the posterior ditto . . .	0·22
Principal focal distance of ditto . .	1·73
Distance of the centre of the optic nerve from the central fold in the axis of vision	0·11
Range of the eye, or diameter of the field of vision	1·100

Refractive powers of the dioptric media by Sir D. Brewster.

Aqueous fluid	1·3366
Outer surface of lens	1·3767
Centre of ditto	1·3990
Mean ditto	1·3839
Vitreous body	1·3394

From the above statement, we gather the following index of refraction.

For the rays of light passing from the aqueous fluid into the outer coat of the lens	1·0466
For the rays passing from the aqueous fluid into the lens, taking as a mean	1·0353
For the rays passing from the outer coat of the lens into the vitreous body	0· 93

SECTION III.

In the third section of this treatise, it is proposed to describe the structures which are accessory to the globe of the eye; and in the fourth, those parts which are more strictly denominated the "tutamina oculi," or defenses of the organ of vision. The former parts contribute to the growth, and nourishment and motions of the globe; the latter serve to protect this delicate organ from external annoyance and injury.

Inasmuch, however, as the bones will come to be often mentioned, in the course of the description of the accessory structures they surround and enclose, the orbit, which constitutes one of the principal defences of the organ, will necessarily be taken somewhat out of the course originally proposed to be adopted, in describing each part strictly in the order of its natural and regular succession. In giving therefore a table of the structures in question, I am compelled to insert amongst the accessories of the globe of the eye, the orbit, which otherwise and with more propriety, perhaps, would have appeared at the head of the "tutamina oculi."

Thf Accessories of the Eye.

1st. The Orbit, or Defensive structure.	*a.* Its general figure and relations. *b.* The peculiarities and disposition of the several component bones.

2nd. THE CONTENTS OF THE ORBIT.
- *a.* Muscles proper to the globe of the eye
- *b.* Arteries and veins
- *c.* Nerves and ganglia
- *d.* Fat, membranes, &c. &c.

THE ORBITS.

The two orbits are placed in the front of the head and at the upper part of the face, being formed of the cranial bones above, and by the facial bones below. They are separated from each other by the nose. Viewed in a skull that has been macerated, their anterior aspects will not be found in the same plane, owing to the oblique bearing of their respective circumferences; neither do the axes of the orbits precisely correspond, although the eyes which they contain are in direct and perfect parallelism. The orbits are in shape conoidal, having their bases open in front: they are not, however, perfect cones, but rather pyramids with four unequally depressed sides, so placed with respect to each other, that their apices, if prolonged behind, would meet; whilst lines still further extended, through the axis of each orbit, would cross each other upon the processus olivaris of the sphenoid bone.

If a horizontal section, or in other words, if a plane be drawn, through the external and internal angular processes of the frontal bone, backwards as far as the apices of one of these pyramids, it will present two sides of a nearly equilateral triangle. The nasal or inner paries is almost parallel with the

corresponding one of the opposite side; the outer one faces towards the temporal fossa; and a line drawn to complete the triangle will represent the base of the orbit, where it is open in front.

The superior side, or *roof* of the pyramidal orbit, is smooth and arched, with a slight inclination downwards and outwards.

The *floor* of the orbit, slopes from the nasal side also downwards and outwards: it is smooth, and slightly concave, with its concavity directed upwards, or facing the roof.

The outer, or *temporal side* of the orbit is triangular, and partly separated from the floor and roof by two deep fissures; it runs obliquely backwards towards the apex.

The inner, or *nasal wall* is nearly parallel with the corresponding part of the opposite orbit, and passes directly backwards towards the optic foramen, which is situated in, or rather perforates, the very *apex* of the orbit.

The *circumference*, which surrounds the *base* of the orbit, is well defined, except at its inner edge, where it is continuous with the nose; its general aspect or bearing is oblique, and slopes downwards, backwards and outwards. Hence the parallel nasal sides of the two orbits project much more anteriorly than any of the others; an effect which is aided by the bones of the nose, that separate the two orbits.

Each of these cavities is composed of seven bones, but as three of the bones are common to both, eleven only enter into the composition of the two. Of the seven bones, the three azygos (the frontal, æthmoid,

and sphenoid,) contribute equally to the formation of both orbits.

The roof of the orbit is made up of	The frontal bone, and Sphenoid.
The floor, of	The malar bone, The superior maxillary, and Palatine.
The temporal side, of	The sphenoid bone, and Malar.
The inner side, of	The superior maxillary, The os unguis, and The pars plana of the æthmoid bone.

The following peculiarities may be observed in each bone, as either directly or indirectly, connected with the organ of vision.

The roof of the orbit has been described as formed by the junction of the frontal and sphenoid bones. The orbitar plate of the former is nearly three-fourths greater in extent, at this point, than that of the latter bone; of which a small triangular portion called the lesser wing, or the wing of Ingrassias, is perforated in the very axis of the orbit, by a round hole known as the foramen opticum, giving entrance to the optic nerve, and the ophthalmic artery.

This foramen is surrounded by many muscles proper to the globe of the eye, and to the upper eyelid. Below this point the wing of Ingrassias is observed to be free, and separated from the outer side of the orbit by a deep fissure, which will be more particularly described hereafter under the name of "foramen lacerum orbitale superius," or sphenoid fissure, as

contra-distinguished from the spheno-maxillary fissure. The anterior part of the roof is bounded by the strong and well defined orbitar ridge of the frontal bone, uniting at the inner side with the ascending process of the superior maxillary bone, forming the internal angular process. At the outer side, the external angular process is produced by the junction of the frontal with the malar bone. Immediately within the orbitar ridge, and at the inner angle, a small depression is placed, sometimes made rough by a spicula of bone, and more easily detected by the finger than the eye; this gives attachment to the pulley of the superior oblique muscle of the globe. About three-fifths of an inch from the internal angle of the frontal bone, the orbitar ridge is interrupted by a deep notch, sometimes formed into a complete foramen, in the hollow of which, the frontal division of the ophthalmic branch of the fifth pair of nerves passes out from the orbit to gain the forehead. The ophthalmic artery accompanies the nerve, and each of them at this point gives off a slender twig, that passes through a minute foramen in the centre of the notch, to be distributed to the membrane of the frontal sinus. A similar indentation, but much shallower than the notch, is found at its inner side, and is occupied in a like manner by a branch of the frontal nerve and artery. Above the inner angle and orbitar ridge a rough prominence is found, more or less developed in different individuals, and commonly most observable in male subjects. This part forms the superciliary tuberosity, which diverges from its fellow of the opposite

side, somewhat arched, and in direction and shape resembling an inverted comma (‘). It is perforated by several minute holes, which give to it a somewhat spongy appearance. Corresponding in shape to and arising from it, is the corrugator muscle of the eyebrow, which is placed immediately above the orbitar ridge.

Above the outer angle, but within the orbit itself, is felt rather than seen, a shallow depression destined for the reception of the lachrymal gland.

Two foramina yet remain to be described; these are found at a little distance from each other, in the suture uniting the pars plana of the æthmoid with the frontal bone; they are usually common to each, though sometimes confined and proper to the frontal bone. They are known under the names of foramina orbitaria interna, and are distinguished from each other by the addition of anterius and posterius. Through the anterior foramen pass the nasal twig of the first division of the fifth pair of nerves, and a branch of the ophthalmic artery; through the posterior solely an arterial twig.

The great fissure, separating the roof from the outer side of the orbit, and dividing the smaller from the greater wing of the sphenoid bone, is known by the name of the sphenoid fissure, or foramen lacerum orbitale superius. Its form is triangular, having its base directed towards the bottom of the orbit, and separated by a narrow neck of bone from the optic foramen; from this point it is directed upwards and outwards towards the junction of the frontal with the greater wing of the sphenoid bone,—a junction

which converts the fissure into a foramen. Through this opening the third, fourth, and first division of the fifth, and sixth pair of nerves, enter from the brain; whilst by the same passage the ophthalmic veins leave the orbit to gain the cavernous sinus between the laminæ of the dura mater. Inasmuch as these trunks do not entirely occupy the area of the fissure, the remaining space is covered and filled up by the strong fibrous membrane that lines the orbit generally.

The outer side of the orbit is formed by the sphenoid and malar bones uniting into a sort of triangular plane, the apex of which is bounded by the upper, and as we shall presently also see, by the lower lacerated openings; or, to speak in more strictly anatomical language, by the sphenoid, and spheno-maxillary fissures. The anterior and external edge of this plane commences above at the articulation of the outer angular process of the frontal bone with the ascending process of the malar bone. Thus both the inner and outer angular process of the orbit may be said to be formed by the union of the facial with the cranial bones. The separation of the roof from the outer side of the orbit, is formed by a line drawn from the apex through the outer angular process; while the floor is separated by a similar imaginary line, prolonged in the direction of the spheno-maxillary fissure, through the tuberosity of the malar bone, which completes the limits of the anterior circumference of this side. This triangular plane is more flat than either the roof, or the floor, and is perforated by two small holes, through which

some minute twigs of the lachrymal nerve pass to anastomose with the facial nerve upon the cheek. Some anastomoses take place by the same foramina between the external and internal carotid arteries.

The spheno-maxillary fissure, or foramen lacerum orbitale inferius, is placed between the orbitar plate of the sphenoid bone and that of the superior maxillary—it is of greater extent, and more irregular in shape than the sphenoid fissure; its direction is from the apex of the orbit, outwards, downwards, and forwards, and, as we have before observed, separates the outer side from the floor of the orbit. This space gives passage to some vascular twigs, and to a small branch of the lachrymal nerve to anastomose with the superior maxillary nerves; more particularly, however, to the large branch of the second division of the fifth pair of nerves, destined to supply the skin of the cheek and lower eyelid. The remaining space is filled up in the recent subject by fat and cellular membrane.

The floor of the orbit is chiefly composed of the orbitar plate of the superior maxillary bone, which is smooth and hollowed out to serve as the resting-place for the globe of the eye, and that portion of the malar bone below the imaginary line heretofore mentioned. Anteriorly it is bounded by the orbitar ridge continued from the malar bone to the base of the os unguis; posteriorly it is finished by the articulation of the superior maxillary with the palate bone, which, however small, helps to complete the floor forming its extreme apex. At the inner side it joins in front with the base of the os unguis, and

between this point and the palate bone, with the pars plana of the æthmoid bone. The orbitar plate of the superior maxillary bone or floor of the orbit, is composed of two thin laminæ of bone, enclosing between them the canal of the infrà-orbitar nerve; the commencement of the canal, is, however, uncovered above for nearly one-third of its extent at the most posterior part. Again, the floor of the orbit, forms the roof to the antrum Highmorianum, which, in a pathological sense, is exceedingly interesting to the ophthalmic surgeon, since the diseases to which this cavity is liable, include exostosis, caries of the floor of the orbit, ulcerations of the eyelids, ectropion, and various other morbid states, implicating the organ of vision. Towards the junction of the superior maxillary bone with the os unguis and within the margin of the orbit, the inferior oblique muscle of the eye takes its origin. Finally, the inner wall of the orbit proceeds, as stated above, almost directly backwards, parallel with its fellow of the opposite orbit. It is made up of the ascending process of the superior maxillary bone in front, forming the feebly defined orbitar ridge, and hemming in the os unguis. This latter bone, a mere scale, covers at its inner or nasal side the anterior æthmoidal cells, but on its orbitar or outer surface it is divided into two portions by an acute perpendicular ridge; the anterior of the two divisions in conjunction with the superior maxillary bone forms a deep groove at its upper part, which lodges the lachrymal sac; then passing downwards, backwards, and inwards, towards the lower cham-

bers of the nose, it takes the name of "ductus ad nasum" or lachrymal channel. The posterior division joins with the pars plana of the æthmoid bone, which being flat and equal completes the inner wall of this four-sided pyramid. The pars plana is notched at its upper edge, commonly in one, sometimes in two places, to complete with the frontal bone the anterior and posterior orbitar foramina.

Thus we are to consider the orbit built up, as it were, by the complex articulation of several bones, formed of four sides, and bounded in three-fourths of its extent by a well defined and prominent ridge; the remaining fourth side, common to the nose as well as to the orbit, assists in forming that division between the two, which is appropriated to the organ of smell. From the projection of this inner beyond the outer side we have demonstrated the general obliquity of the axis of the orbit; the globe of the eye itself does not partake of this direction, on the contrary its aspect is directly forwards. From this circumstance it results, that the eyes are more completely defended at their inner than outer sides, and this apparent inconvenience or defect, is amply compensated in the much greater extent of the field of vision thereby produced. Winslow in his "Anatomy of the Head," has well described this position of the eyes in relation to the orbits. "The globe," says he, "is naturally placed in such a manner, as that during the inaction or equilibrium of all the muscles, the pupil is turned directly forwards, the inner edge of the orbit is opposite to the middle of the inside of the globe, the outer edge of the orbit

because of its obliquity is behind the middle of the outside of the globe."

The orbit is lined by a dense periosteum, sometimes called periorbita, which is continuous with the dura mater at the great cerebral openings; with the periosteum of the base at the spheno maxillary fissure—anteriorly with the pericranium of the forehead, and the periosteum of the face, as well as with the tarsal ligaments of the eyelids. The orbit when viewed in the recent subject presents a very different aspect from what it does in the macerated skull. This arises from the manner in which the membrane is continued over the larger openings of this cavity, merely allowing room for the passage of the nerves and arterial trunks, that enter to supply the globe of the eye and its accessories.

THE MUSCLES OF THE EYEBALL.

The orbit contains in all seven muscles; of these six are proper to the eyeball, the seventh belongs to the upper eyelid, and its description will therefore be deferred till the defences of the eye come under consideration.

Owing to the almost universally prevailing custom, in the earlier periods of our art, of confining direct anatomical observation exclusively to the dissection of brute animals, the ancients were exposed to many and great errors in their inferred descriptions of the anatomy of man. Thus they added to the eye a certain muscle, which Vesalius describes, evidently

surprised at the inaccurate accounts given of it by preceding observers, who had divided it into two, three, and in some cases even into four palpable and distinct muscles. Arguing with great gravity on the uses, and even on the necessity for the presence of the part in question, he lays claim to the actual discovery of it in these words. "Musculus hic nullam prorsus descriptionem obtinet."—"Unde etiam miror, hunc non unius musculi loco, ab anatomicis enumeratum fuisse, sed ab aliis duorum, ab aliis trium, &c." From the very excellent drawing which Vesalius has given of this muscle, it is clear that his description of it, as well as the descriptions of his predecessors, had been derived from the suspensory or retractor muscle of certain quadrupeds. This error was first pointed out by Fallopius. Columbus again was widely wrong, he not only invented a new membrane formed by the union of the four straight muscles, and to which the examination of the eyes of animals might have led him, but he even described the superior oblique muscle as belonging to the eyelids, under the name of "tertius palpebrarum." For a full explanation of the progress of the myology of the human eye, I must refer my readers to Zinn, who has devoted a chapter of his admirable work to an elaborate survey of its history.

There are two classes of muscles, by which all the varied movements of the eyeball are performed; these are distinguished, owing to their general direction, by the terms straight, and oblique. The former are four in number, flat, and ribbon-shaped, rising fleshy and tendinous from the posterior part of the

orbit, surrounding and embracing the optic nerve at its immediate entrance into this cavity, and inserted at four cardinal points into the anterior part of the sclerotic coat by broad and thin tendons.

Various, indeed, are the names that have been applied to these muscles according to the different systems adopted. Thus, one particular muscle has received no less than twelve different appellations. Vesalius, for instance, in a certain numerical and perfectly arbitrary order, has called the superior straight muscle of the eye the "tertius oculi." Fallopius, still more obscure, calls it "unus ex quatuor, qui rectis motibus præfecti." Fabricius applies to the same muscle, the term "rectus superior." Molinet, according to a certain physiognomical system, names it "superbus:" others, the "elevator oculi," &c. &c.

The same observation applies to nearly all the muscles of the eye. To avoid confusion, therefore, we shall name them indifferently, according either to their position or their function: for example, the rectus superior, as synonimous with levator oculi, and either term to be used at pleasure.

The Four Straight Muscles.

The four straight muscles arise immediately around the foramen opticum, which perforates the base of the wing of Ingrassias, but neither separately, nor altogether by a common root. Thus the rectus superior rises conjointly with the levator of the upper

eyelid; the three others by a fascia common to them and sometimes also to the superior oblique. As the nature and mode of insertion of all these straight muscles are very similar in all essential points, although opposed in direction, a particular description of one will suffice for all.

The levator oculi, or superior straight muscle, arises in common with the levator of the upper eyelid, at the superior edge of the optic foramen, which is here slightly prominent and rough, and in the angle formed between the periosteum of the orbit and the sheath of the optic nerve, which are at this point closely connected with each other, and continuous with the dura mater within the cranium. Its origin is fleshy interspersed with a few tendinous threads, which run intermingled with the muscular fibres, both at its upper and lower sides, where the muscle is exposed to the friction of the levator of the upper lid above, and of the globe below. It is soon separated from the sheath of the optic nerve by small lobules of oily fat, and from the globe of the eye, by an interposed cellular membrane to be more particularly adverted to hereafter. Its fleshy and ribbon-shaped belly advances above the globe of the eye, separated from the roof of the orbit, by the levator of the upper eyelid. At somewhat about two-thirds of its whole course it begins to send off a fine broad and glistening tendon, that bends over, and is closely applied to the fore part of the sclerotic coat. This tendon is inserted, by a beautifully thin edge, into the sclerotic at about one-fifth of an inch from its junction with the cornea. Its fleshy

belly is red and flat, or nearly so, and about half an inch in breadth.

Although one of the straight muscles, properly so called, its course is somewhat oblique; because as the eye is nearly in the centre of the orbit, and as the muscle is inserted into the median centre of the eye, its origin will be found considerably to the inner side of this line. The same remark applies to the inferior, and still more forcibly to the external straight muscle; the internal one only, owing to the direction of the inner wall of the orbit, preserves a direct course from behind forwards. All the straight muscles, however, *bend* considerably towards the front of the eye, since their tendons are closely applied to, and follow the convexity of the anterior part of the sclerotic coat.

The internal, inferior, and in part the external straight muscles, arise by a common fascia. This aponeurosis, semi-circular in shape, is closely attached to the elevated ridge at the under part of the circumference of the optic foramen, and forms a firm point of adhesion for these muscles.

The depressor oculi, or *inferior straight muscle*, commences by uniting with the internal and one of the heads of the external, in a semi-tendinous bundle. From this union it soon separates, and assuming a narrow, fleshy, ribbon-like form, it pursues a course directly opposed to the levator oculi, and finally is inserted into the under and fore part of the sclerotic coat. To this muscle the name of "humilis" has been applied.

The internal, or *adductor oculi muscle*, arises from

the above-mentioned fascia, pursues a straight course to the inner side of the globe of the eye, and is inserted into the inner and fore part of the sclerotic coat, midway between the levator and depressor muscles. Some anatomists describe this muscle as two-headed: this may, indeed, sometimes be the case, since it is not rare to find varieties in the origins of the muscles generally. Perhaps, however, the fan-like divergence of its primary fibres, where applied against the sheath of the optic nerve, may have led to some confusion upon this subject, especially as nothing is more easy, than by roughly detaching it, to produce the appearance adverted to. This muscle has been named "bibitorius," because it draws the eye towards the nose in the act of drinking.

The abductor, or *external straight muscle*, has undoubtedly a double origin, and in the variety of names given to this muscle, it is somewhat singular that it should never have been denominated the "biceps oculi." It is, indeed, of some importance to mark its double head, since several nerves of consequence enter the orbit between these two portions. The lower head, and the larger of the two, arises from the tendinous fascia, in common with the depressor oculi, with which it is connected for some little distance before it separates into a distinct muscle. The outer head rises somewhat above this last, from the periosteum of the orbit, a little to the outside of the optic foramen, and at the very edge of the sphenoid fissure. This origin passes over, or bridges as it were, the entrance of the third, nasal division of the fifth, and sixth pair of nerves. Both

its origins then unite and form a fleshy belly, whose tendon is inserted into the anterior and outer part of the sclerotic coat. This is the "iracundus" of Molinet. The abductor muscle is the longest and most oblique of the four straight muscles of the eye—the adductor is the shortest and most direct in its course; the depressor and levator oculi holding a middle place, in regard both to length and direction.

The nerves which supply the voluntary power to the straight muscles, are the third pair, dividing into a branch for the levator, depressor, and adductor muscles; and the sixth pair, specially destined to the abductor oculi. From whatever source derived, the nerves always enter the muscles in a similar manner, on the ocular aspect at the posterior quarter of their length; they divide into two, three, or more filaments, before penetrating between the fibres.

The muscles are supplied with blood from irregular branches of the ophthalmic artery, called the muscular.

The Oblique Muscles.

The oblique muscles, two in number, the superior and inferior, differ much from the preceding, not only in the obliquity of their position, but in the points of their insertion, and in their action upon the globe of the eye. We have seen that the tendons of the four straight muscles are inserted into the anterior part of the sclerotic coat, not far from its junction with the cornea, applied against and

bending over the globe from its transverse centre forwards. On the other hand, the oblique muscles are attached to the eyeball *behind* its centre of motion, commencing at the posterior part of the middle third of the sclerotic coat. We shall soon see how widely different are their actions, owing to the peculiarities of their several attachments. To these muscles the name of "circumductors of the eye" has been given.

The obliquus superior muscle, arises by a fine tendinous head from the sphenoid bone, not far from the optic foramen, and between the origins of the superior and internal straight muscles. It does not mingle with these muscles, nor with the common fascia before mentioned; but gradually increasing in bulk, instead of being like all the other muscles of the eye flat and ribbon-shaped, it is round and tapered, taking a slightly oblique course, upwards, forwards, and inwards, along the suture of the frontal and æthmoid bones. As it approaches the fore part of the orbit, it sends off a fine tendon, which pursues the original direction of the muscle, until it meets with a small cartilaginous loop or pulley, fixed immediately behind the internal angular process of the frontal bone, and midway between it and the superciliary notch: at this point, the tendon is round and smooth. Having passed through the loop, it suddenly turns backwards, downwards, and outwards, until it reaches the posterior part of the globe of the eye. In this part of its course, it passes over the adductor and beneath the levator muscles; and is finally inserted by a broad and thin tendon, which

has been gradually diverging and expanding from the pulley, into the posterior third of the sclerotic coat, between the bellies of the levator and abductor oculi muscles. The tendon, as it approaches and passes the pulley, is round; but as it proceeds towards the eye, it becomes more and more flat, terminating fan-like with divergent fibres, giving it a triangular shape from the pulley to the point of its insertion.

It appears that Galen was profoundly ignorant of the origin of this muscle, as in his description of the muscles, he says, that the superior oblique arises from the inner angle of the eye: and Vesalius, again, who gives the commencement of the muscle correctly, from the neighbourhood of the optic foramen, makes no mention of the pulley; which is the more remarkable, since the very error of Galen as to the immediate origin, clearly refers to this point. Columbus falls into a third kind of mistake, who, while he describes the muscle correctly, pursues it no farther than the inner angle of the eye, and calls it "tertius palpebrarum;" evidently inferring that it ceased at this point, by being inserted into the eyelids. Fallopius was, I believe, the first who pointed out the pulley; and the anatomy of this muscle was perfected by Eustachius. The best account of it, however, is given by Albinus, in his excellent work of "The History of the Muscles in Man." The nerve specially destined to the superior oblique muscle, is the fourth pair.

The pulley, is formed by a semi-circular cartilage, which is fixed at each horn by ligaments to the

frontal bone, at the point indicated when speaking of the roof of the orbit. It offers a smooth groove for the play of the round part of the tendon of the superior oblique, while to facilitate the motion where these two parts are in contact, we find a small *bursa mucosa* lubricating the tendon, which is accompanied from thence to the insertion by, and involved in, a loose cellular sheath lost afterwards by being confounded with the membranous coverings of the straight muscles.

The inferior oblique muscle, differs in form, origin, and direction from all the preceding muscles. It commences near the front of the orbit, from a slightly roughened line immediately below the groove of the lachrymal duct as seen in the orbit, and within the prominent orbitar ridge, formed by the superior maxillary bone: from thence, by fleshy fibres, as far back as the thin plate of bone that covers the canal of the infrà-orbitary nerve. From these attachments the muscle proceeds, ribbon-like, along the floor of the orbit, in a semi-circular form and oblique direction, outwards and backwards, at first between the floor of the orbit and the depressor oculi, and then ascending, is applied against the globe, to be inserted by a broad tendon into the posterior and outer part of the sclerotic coat, nearly opposite to the tendon of the superior oblique muscle, and immediately above the line of the belly of the abductor oculi. This muscle is supplied by a branch of the third pair of nerves: it is important to mark, however, the fact of this branch of the common oculo-motor nerve invariably receiving a twig from the lenticular gang-

lion. A few of the primary fibres of this muscle are said to be attached to the lachrymal sac itself.

The Actions of the Muscles.

When any one of *the straight muscles* contracts, its tendency is of course to bring its point of insertion towards the origin or fixed point, in a straight line between the two: the action of each, therefore, is very properly expressed by the names these muscles have received, as levator, depressor, abductor, adductor; the two latter having reference to the mesial line of the body. When either of the lateral muscles acts together with the upper, or lower one, the eye will be carried in a line drawn directly between the two, if the forces be equal; or it will be inclined to that side on which the contraction shall be the greatest. If all the straight muscles act together, they will retract the eye further within the orbit. As, however, the ball of the eye is nearly spherical, the contraction of any one of them will slightly *rotate* the eye, but in a direction opposed to that of the oblique muscles.

In considering the action of *the superior oblique muscle,* particular notice should be taken of the point of insertion, and of the trochlea or pulley. The point to be moved is the outer side of the globe, posterior to its centre of motion taken as a vertical centre, and considerably behind the insertion of the straight muscles. The pulley, or fixed point, is anterior to the insertion, above, and to its inner side.

Thus contraction of this muscle, by bringing the insertion towards the pulley, has a tendency to direct the back of the globe forwards and inwards; but as its tendon embraces, as it were, a spherical body, and is implanted obliquely, it rolls the eye upon its axis; and in bringing the posterior part upwards to the inner angle of the frontal bone, it depresses the fore part of the globe, and the pupil is directed downwards and outwards, towards the promontory of the cheek. Such is the action described by Albinus: and by actual experiments, and by its accordance with the known laws of muscular contraction, I am persuaded of its correctness.

The action of the inferior oblique muscle, is to roll the eye upwards and inwards under the superior eyelid.

The actions of the oblique muscles, have been the subject of much dispute amongst anatomists; and even at the present day, the question is far from being completely set at rest. As the point is not without its interest, let us take a rapid view of the opinions of some of the more eminent ancient and modern anatomical writers.

It is clear that Galen and other authors downwards to the time of Fallopius, who discovered the pulley of the superior oblique, must have been ignorant of the true action of this muscle; since this discovery, however, little doubt has existed upon this head, but with regard to the action of the inferior oblique much variety of opinion has existed. Albinus states that this muscle, opposed to the superior oblique, directs the pupil upwards towards the tail

of the eyebrow (" caudam supercilii ") or towards the temple, while it rotates the eye from the outer side, along the floor and inner edge of the orbit. It also draws the posterior part of the globe, like the superior oblique, forwards but downwards. Kenneday, in his " ophthalmographia," says, that " the superior oblique draws the eye forwards and directs the pupil downwards. The inferior oblique draws it forwards and upwards, and acting together draws the globe fixedly towards the nose." This author says nothing of the rotating action, or of the direction of the pupil to either side. Dr. Porterfield, who is exceedingly precise in his description of the action of these muscles, gives that of the superior oblique as above: but with regard to the lower, which he calls the " the brevissimus oculi," merely states it, as rolling the eye about its axis from the nose, at the same time drawing the globe forwards, and directing the pupil upwards. A short way further on, he says, " Though the action of these muscles seems pretty evident, yet there is scarcely any part of the human body about which anatomists have differed more than in assigning them their proper offices."

The celebrated Cowper, whose opinion Porterfield followed, is among the first who began to reason justly concerning them. His opinion of the office of the oblique muscles consists, principally, in their conjoint action; that they preserve the eye suspended in its orbit, for the better receiving the motions of the straight muscles, and antagonise each other. Somewhat similar to this is the doctrine of Winslow, who says, that " the use of the oblique is chiefly to

balance that of the recti, and to support the globe in the actions already mentioned." Zinn does not describe the actions of these muscles. Bichat writes, " Les movemens de rotation, l'un en dedans, l'autre in dehors, mouvemens dans lesquel l'œil ne se deplace point, mais se meut seulement sur son axe, sont dus, le premier au grande rotateur (s. oblique). Le second au petit, muscle antagoniste, l'un de l'autre sous ce rapport." Meckel's opinion is as follows, " The inferior oblique muscle rolls the eye upon its axis, first, outwardly, then downwards, and lastly inwards, at the same time bringing it forwards." Sir C. Bell has discussed the action of these muscles at great length. The action of the superior oblique, according to this eminent physiologist, consists in turning the pupil downwards and outwards, the inferior upwards and inwards under the upper eyelid, at the same time they perform the traversing motions of the globe independent of the will, or in other words they belong to the class of involuntary movements. To prove this point, Sir C. Bell has made many observation upon the eye, in states of disease, when under artificial excitement, upon its position during sleep, &c.; he has also instituted some ingenious experiments which lead him to the conclusion offered in a note at page 211 of his 4to. edition, on the Nervous System of the Human Body, (1830). He found that during sleep, or when the eye was involuntarily guarded from the effects of a strong light, the pupil was rolled upwards and inwards, under the inner canthus of the upper lid. The same effect was produced, when an attempt was

made to close the eye, the lids being forcibly held open: also in difficult respiration, in sneezing, and the like. He refers this action to the agency of the fourth pair of nerves as instrumental in aiding this involuntary motion, but as this nerve is solely distributed to the superior oblique muscle, and as the contraction of this muscle turns the pupil downwards and outwards, he has recourse to the new theory as explained in the note alluded to, to which especial attention is requested. In the general text, after having detailed the curious origin of this nerve, and its sole destination, he proceeds, "What office can this nerve have in reference to this one muscle? we now reflect with increased interest on the offices of the oblique muscles of the eye, observing that they produce an insensible rolling of the eyeball, and hold it in a state of suspension between them; we have seen the effect of dividing the superior oblique, was to cause the eye to roll more forcibly upwards, and if we suppose the effect of the fourth pair of nerves is, *on certain occasions to cause a relaxation of the muscle to which it goes*, the eyeball must be rolled upwards." To this paragraph is appended the following note, "The nerves have been considered so generally, as the instruments for stimulating the muscles, without any thought of their acting in the opposite capacity, that some additional illustration may be necessary here. Through the nerves is established the connection between the muscles, not only that connection, by which the muscles combine to one effort, but also that relation between the classes of muscles in which the one relaxes while the other contracts.

I appended a weight to the tendon of an extensor muscle, which gently stretched it, and drew out the muscle; and I found the contraction of the opponent flexor was attended with a descent of the weight, which indicated the relaxation of the extensor. To establish this connection between two classes of muscles, whether they be grouped together, as in the limbs, or scattered widely, as the muscles of respiration, there must be particular and appropriate nerves to form this double bond, to cause them to conspire in relaxation, as well as to combine in contraction. If such a relationship be established, through the distribution of the nerves, and between the muscles of the eyelids, and the superior oblique muscle of the eyeball, the one will relax while the other contracts." I confess this reasoning to be somewhat startling, and if established, is of great importance in physiology: we, in consequence, ask, if the fourth pair of nerves relax the superior oblique "occasionally," does it not on other occasions cause it to contract? or, in other words, does not this theory imply two very opposite modes of action to this nerve, since the very term to "cause a relaxation" implies an active influence of the nerve? If, however, we look to the source of the nervous supply to the inferior oblique muscle, we find that although it receives a branch from the voluntary third pair, yet we also invariably find that this branch is joined by a twig from the lenticular ganglion, or from the involuntary system of nerves. This, I believe, at once changes the function of this muscle, and takes it out of that class, which is subjected to

the entire control of the will. We have no direct evidence, anatomical or otherwise, of any such property being possessed by the fourth pair of nerves. If, therefore, the superior oblique simply ceases to contract, that is, if the active influence of the mind ceases to exert its power over this muscle through the medium of its nerve, as is the case with regard to all the voluntary muscles at certain intervals, *the involuntary* contraction of the inferior oblique will immediately carry the pupil upwards and inwards, which is found to be the case, when, from whatever cause, the exercise of volition upon the other muscles is suspended.

Besides the above-mentioned actions of the oblique muscles, it should be observed, that when they both act in concert, they bring the eye forwards, as in the operation of staring, or looking fixedly at any object. When they act alternately, they produce the traversing motions of the eyeball, and the vibratory or tremulous motion so remarkable, at times, in the eyes of children born blind.

ARTERIES AND VEINS OF THE ORBIT.

The Ophthalmic Artery.

All the arteries of the human body are more or less subject to deviations in their origin and distribution; and none, perhaps, offer more frequent varieties in different individuals, than the one which heads this paragraph: consequently, the description of this vessel, taken from any one subject, should be considered in detail as applicable to that only from which it was selected, not as a distribution common to all. Haller has recorded the varieties of the primary and secondary branches of the ophthalmic artery, in no fewer than twenty-four bodies, specially injected with coloured fluids, and traced with the greatest care to their ultimate terminations. Zinn expressed his regret, that he did not possess equal facilities of anatomical examination with his illustrious friend, but he has, nevertheless, given us a particularly minute, and correct account of the course, division, and inosculations of the smaller arteries of the interior of the eye. Add to the labours of these two anatomists, the valuable work on the arteries, by the late Dr. Barclay of Edinburgh, and a most full and accurate knowledge of the progress of the ophthalmic artery and its orbitar branches may be acquired. I shall, in the first instance, content myself with giving a description of the course which

this artery commonly takes, and subsequently, an account of the most frequent varieties observed by these authors.

The internal carotid artery, immediately after emerging from the cavernous sinus within the cranium, and as it ascends by the side of the anterior clinoid process, gives off its first considerable branch, *the ophthalmic artery.* This vessel springs from the outer and anterior part of the internal carotid trunk at the convexity which it makes at this place. The ophthalmic artery is at first placed below, and to the outer side of the optic nerve, to whose sheath it is closely attached by dense fibres of dura mater. It next passes through the optic foramen, and upon its entry into the orbit it is still below and to the outer side of the nerve, having immediately before it the lenticular ganglion. Speedily ascending to the level of the nerve it gives off some important branches.

The ophthalmic artery still ascending, passes with an obliquity forwards and inwards, above and across the optic nerve. In this part of its course, it gives off four or five secondary branches.

It is now directed forwards, at the inner side of the nerve, lying between the adductor and superior oblique muscles, and finishes its course at the inner canthus of the eye by dividing it into two terminal ramifications.

Throughout the whole of its progress the ophthalmic is a very tortuous artery, and its branches both in name and destination will be found to bear a resemblance to the distribution of the first division of the fifth pair of nerves, more especially if it be

divided into three portions, as in the following table, which will not only aid the memory, but greatly facilitate the description.

BRANCHES OF THE OPHTHALMIC ARTERY.

First third of its course	1. The lachrymal branch. 2. The central branch of the retina. 3. The inferior muscular branch. 4. Posterior choroidal branches.
Second third	5. The short ciliary branches. 6. The long ciliary ditto. 7. The suprá-orbital branch. 8. The superior muscular ditto.
Third division of its course	9. The posterior æthmoidal branch. 10. The anterior æthmoidal ditto. 11. The superior and inferior palpebral branch. 12. The nasal branch. 13. The frontal ditto.

1. *The lachrymal artery* is the largest of those branches which are given off in the first part of the course of the ophthalmic trunk. It arises almost at the point where this vessel enters the orbit, and sends minute ramuli to the periosteum of the roof and inner side of this cavity, also some twigs which twine round the third and sixth pair of nerves; and a larger division to the fleshy belly of the abductor oculi muscle. It then passes outwards and forwards, between the abductor muscle and the external wall of the orbit, as far as the lachrymal gland. Before it arrives at this point, it gives off at its outer side, one or two small

vessels, that inosculate through the spheno-maxillary fissure with ramifications of the internal maxillary artery. A little further onward it furnishes a twig, that perforates the malar foramen, and having given a supply to the diplöe or cellular structure of the malar bone, it appears upon the cheek to anastomose with the transverse facial branches of the temporal artery. At its inner side, the lachrymal artery gives several minute vessels to the levator oculi muscle; and having reached the lachrymal gland, where it is situated above and a little to its outer side, it divides into many ramuli, supplying to the gland the blood necessary for the secretion of the tears. Beyond the gland, the terminal divisions of the lachrymal artery are found distributed to the upper eyelid. Of these, some, taking a direction outwards, meet at the external canthus with branches of the temporal artery, with these they anastomose in the skin of the lids and neighbouring parts. The central of the terminal branches are distributed to the orbicularis palpebrarum muscle, to the fat, skin, and to conjunctival membrane of the upper eyelid, where they meet and inosculate with branches from the superior muscular division of the ophthalmic artery. Finally those vessels most to the inner side anastomose with divisions of the frontal, and the proper tarsal arches of the palpebral arteries.

2. *The central artery of the retina* may be divided into two sets, both requiring, on account of their minuteness, the most careful injections to display them. The first division consists of slender twigs, which are distributed to the lenticular ganglion, and

twine around the sheath of the optic nerve, anastomosing in the soft fat about the ganglion with some of the short ciliary arteries. The second and most important branch penetrates the sheath of the optic nerve, with an obliquity from behind forwards; it gives some minute vessels to the fibrillæ of medullary matter of which the nerve is composed, and whose centre it now gains. Arriving with the optic nerve at the posterior part of the sclerotic coat, it penetrates through the centre of the cribriform lamella, by that hole which has been called the "porus opticus;" thence having gained the inner surface of the retina, it divides into three principal branches: two of these are destined to the retina, the other to the supply of the vitreous and lenticular bodies.

Of the two branches distributed to the retina, one passes above, and one beneath the entry of the optic nerve, in a curvilinear direction, giving off numerous subdivisions from the convexity and concavity of their course. These anastomose so frequently by arches, as to form an intricate net-work of vessels, which has gained for the retina generally its present distinctive appellation, as well as those names by which it was known to the ancients, as "amphiblestroides," or "arachnoides," as Hierophilus called it.

The two main branches of this artery still pass forward, towards the anterior edge of the retina, and there subdividing each into two parts, they anastomose reciprocally to form an undulating circle, around the ultimate circumference of the medullary membrane. Some minute vessels have been seen, occasionally, to pass still more forwards upon the anterior layer

of the canal of Petit, and have given occasion to some authors to describe the retina itself as passing to the very edge of the circumference of the lens. The net-work formed by the numerous subdivisions of this artery, and the fine cellular tissue which connects them and supports the medullary matter of the retina, as the pia mater does that of the brain, have gained for the whole the anatomical term of "tunica vasculosa retinæ."

Immediately upon the separation of the above-described branches to the retina, the central artery terminates in one exceedingly minute vessel, which has received the name of "the central artery of the vitreous humour." In the adult eye, the finest injections, excepting in most rare instances, fail to display its existence; but in the fœtal state it is easily shewn, and its course is then no less remarkable and beautiful than important. It seems to penetrate directly through the vitreous body, without giving off a single branch, until it arrives at the posterior capsule of the lens. Probably, however, this arises from the coarseness of our injections, in consequence of which its branches have escaped detection; though these are doubtless distributed in all directions to supply the hyaloid cells of the vitreous body. (Vide note to page 115.)

The ramifications, which this artery sends to the posterior capsule of the lens, radiate from the centre to the circumference, anastomosing frequently with each other, towards the extreme edge of the capsule. Many authors assert that these minute arteries penetrate the capsule itself, and give branches to the

body of the lens. Under the head of the crystalline lens, I have quoted the authority of Mr. Mackenzie of Glasgow, who has seen in certain stages of inflammation these branches distributed to the substance of the lens, and whose arborescent appearance he has most carefully described.

The late Dr. Barclay, of Edinburgh, in a note to his description of the arteria centralis retinæ, with a candour which constantly accompanies true genius, says, "I must confess, though I never have seen one or other of these branches (vessels to the vitreous and lenticular bodies), I feel no inclination to doubt the veracity or accuracy of those who have mentioned them. Sabatier, however, who has seen the branch that penetrates the substance of the vitreous humour, suspects the existence of the branch or branches, that are said to enter the body of the lens. His suspicions seem to arise from the circumstance, that they have seldom appeared to anatomists after the most anxious and minute research. But if they convey a transparent fluid in their healthy state, how is it possible that they can appear, excepting after rare and lucky injections, or rare cases of violent inflammation? If the natural functions of both the lens and tunica hyaloides require the most perfect degrees of transparency in every part of them, can it be supposed, that their arteries or veins are naturally to admit the gross and opaque parts of the blood; or, whenever we choose to make the experiment, the colouring materials of our injections?" After commenting upon the various hypotheses of the nourishment of the lens, Dr. Barclay concludes

in these words:—"I should be inclined to continue in the old vulgar opinion, that the lens is nourished by transparent vessels; an opinion though vulgar, accompanied only with this single absurdity, if it be an absurdity, that good fortune, which has shewn them occasionally to other anatomists, had never shewn them to Sabatier and Petit."

In the first number of the Journal of the Royal Institution of Great Britain (Oct. 1830), there is a paper entitled, "Contributions to the Physiology of Vision;" and a very curious experiment is quoted from an Essay by Dr. J. Purkinje, of Breslau, by which a luminous figure of the ramifications of the central artery of the retina may easily be seen by any, even little skilled, experimentalist. The following passage is explanatory of this interesting observation:—"If a flame, at about two or three inches distance, is slowly moved before the right eye in various directions, a figure appears painted, as it were, in the luminous area round the flame. The vessels, for such they evidently appear to be, seem to proceed from the insertion of the optic nerve, and consist of two upper and two lower principal branches, which are variously ramified towards the middle of the field of vision, where a dark point is seen, which frequently appears concave. * * * The origin of the vessels is a dark oval spot, with a light areola; the figure itself, or rather fragments of it, are seen under various other circumstances. As was observed above, there can be no doubt that the figure is formed by the central vessels of the retina." To this description is appended a note, well worthy

the attention of the curious, in which directions are given for performing the experiment in a more exact manner, rendering more minute, at the same time more distinct, the ramifications of this spectrum.

3. *The inferior muscular artery* is uncertain in its origin; often arising from the ophthalmic trunk at the outer side of the optic nerve, and sometimes at the inner. Its course as a single vessel is very short, dividing almost immediately into several ramuli, that enter the depressor, the inferior oblique, and adductor oculi muscles, and which penetrate these muscles at the posterior part of their ocular aspect. They also give twigs to the cellular sheaths and tendinous expansions, whence some minute branches penetrate the sclerotic coat near its junction with the cornea, after having freely anastomosed with similar branches from the superior muscular artery. These twigs have received the name of the "anterior ciliary arteries."

4. *The posterior choroidal branches* are numerous and irregular. They are very minute, and enter the sclerotic coat, immediately around the optic nerve, to gain the most posterior portion of the choroid membrane, to which they are distributed, anastomosing frequently with the short ciliary arteries.

In the second part of the course of the ophthalmic artery, or where it crosses above the optic nerve, we have—

5. *The short ciliary arteries*, which are from twelve to fifteen in number, small, delicate, and very tortuous vessels, that inosculate frequently with each other and the preceding arteries, prior to reaching

the globe of the eye. Having arrived at this point, they penetrate the sclerotic a little anterior to the posterior choroidal branches, giving some few twigs to the cellular covering, as well as to the fibrous structure of the sclerotic itself. They are accompanied by nerves of the same name, and penetrate obliquely through those small canals, which were spoken of in the description of the sclerotic. They then enter the choroid membrane, and gain its inner surface. They next radiate forwards, towards the iris; but before reaching this structure, they give numerous branches to the choroid, dividing and subdividing with infinite variety, anastomosing under repeated angles, forming in conjunction with the posterior choroidal vessels a most intricate and splendid mesh-work, admirably described by Zinn in the chapter on the choroid membrane. A successful injection of these arteries gives to the whole an appearance of scarlet velvet, and produces a vascularity as intense as that of a minutely injected fœtal stomach. Towards the anterior part of the choroid coat, the ciliary arteries assume a greater regularity of appearance, and send an infinity of branches to the ciliary processes, some few also to the iris. The former, indeed, are as highly vascular as any part of the choroid coat, and have each of them the appearance of a small pointed leaf folded longitudinally; the nerves of the leaf and their subdivisions convey a pretty accurate idea of the arterial ramifications of the ciliary processes. The iridien branches will be spoken of in conjunction with the following vessels.

6. *The long ciliary arteries*, are two in number,

and commonly arise from the trunk of the ophthalmic artery: their course towards the eye is tortuous, and they are placed at each side of the globe, parallel to its longitudinal diameter. They are, perhaps, the most regular in their direction and distribution of any of the arteries of the orbit.

Having pierced the sclerotic coat, anterior to the line of the last-mentioned arteries, they are placed between it and the choroid membrane; and so precisely do they divide the eye into two horizontal equal portions, that they have been termed the "equators of the eye;" and directions have been laid down, in order to their avoidance in certain surgical operations upon this organ.

As they pass forward, they enter the ciliary circle and gain the greater circumference of the iris, placed more upon its anterior surface than any of the other vessels of the part. Here they divide each into two branches, which passing above and below, and around the circumference of the membrane, mutually anastomose upon the middle perpendicular line of the iris, in order to form a complete circle, called the outer vascular ring. From the lesser or inner circumference of this ring, pass off many straight twigs towards the centre, which gathering together and anastomosing with each other, and also with numerous branches of the anterior ciliary arteries, form a second vascular ring, at the distance of about a line from the pupillary margin of the iris.

The anastomoses of these different vessels are so frequent and so minute, as to require the aid of a magnifying power distinctly to discern them. From

this last ring many ramuli proceed to the very edge of the pupil, where some anatomists describe another and a similar circle of vessels. Between the first ring formed by the double branches of the long ciliary, and of the anterior ciliary arteries, some inosculations take place, leaving small rhomboidal areolæ in their interstices; but the general appearance of a well injected iris shews a radiated disposition of vessels between two well defined circles of tortuous and minute arteries.

The more particular description of the iridien vessels has been given in the section devoted to the organization of the iris; but before I conclude the subject, I may be permitted to observe, that I cannot coincide in the remark of Dr. Harrison, in his "Surgical Anatomy of the Arteries," where he describes the posterior surface of the iris to be more vascular than the anterior. I have invariably found that a successful injection of the arteries of the iris, displays much more perfectly the two arterial circles on the anterior surface, even after the black pigment and ciliary processes have been carefully removed from behind. The brightness or depth of colour of the anterior surface of the iris is insufficient to prevent the accurate display of the vessels, provided the injection has been made with that best of colouring materials, *carmine*.

7. *The suprà-orbitar artery* is of considerable size, frequently as large, and sometimes larger than the lachrymal: its course is forwards to the inner side, and a little above the levator palpebræ superioris muscle, closely accompanying the frontal nerve.

The first branches it gives off are to the levator oculi, and levator palpebræ superioris muscles, ramifications to the frontal nerve, and some anterior ciliary arteries. When the suprà-orbitar artery arrives at the anterior part of the orbit, it sends off a trochlearis branch, some of whose ramuli are distributed to the pulley and sheath of the tendon of the superior oblique muscle; small twigs are also sent to the upper eyelid, and inner canthus of the eye anastomosing with the frontal artery. At this spot the suprà-orbitar artery seems as if increased in size, and passes out of the orbit, ascending through the notch with an accompanying nerve, giving, as it passes this point, a minute ramification that enters a small foramen to supply the lining membrane of the frontal sinuses.

The artery now turns over the brow, dividing into many branches, the outermost of which inosculate with the temporal artery in the skin of the eyebrow and forehead. The central branches pass upward to the forehead, dividing to the occipito-frontalis muscle and skin for some inches space; radiating to anastomose outwards with the temporal, and on the inner side with the frontal artery. The innermost of all the branches expend themselves on the upper eyelid, inosculating with the superior palpebral artery towards the inner angle of the eye. This artery if wounded near the notch, gives some trouble to the surgeon, from its retracting within the orbit and producing extensive ecchymosis amongst the muscles and fat of this cavity.

8. *The superior muscular artery* is not very constant or uniform, its place being often supplied by

any artery in its neighbourhood. Like the inferior branch, it chiefly divides to the muscles in its vicinity, such as to the levator, adductor, and superior oblique muscles. Some of its twigs supply the tendinous expansions, and furnish ramuli to the cellular membrane of the orbit, as well as some anterior ciliary branches.

These anterior ciliary branches, thus derived, as we have seen, from various sources all in the immediate neighbourhood of the anterior part of the eyeball, freely inosculate with each other, prior to piercing the sclerotic coat, a few lines distance from the circumference of the cornea. In the healthy condition of the eye they seldom, except the largest of them, carry red blood, but under inflammation of the deeper seated membranes of the eye, as in *iritis*, their infinite number and great minuteness are evinced by the vascular zone constantly accompanying that disease. Their ultimate terminations have been described in the article upon the organization of the iris.

The third division of the ophthalmic artery, comprehends those vessels which are given off by the ophthalmic, whilst pursuing its course to the inner angle of the eye, to be finally expended upon the forehead and face.

9. *The posterior æthmoidal artery*, which passes below the posterior part of the superior oblique muscle towards the back of the inner wall of the orbit; it first gives a few branches to the periosteum of its vicinity, and then enters the nose by the posterior and internal orbitar foramen, sometimes accom-

panied by a minute filament of the nasal nerve. It ascends from the nose by one of the cribriform foramina of the æthmoid bone, gives a small twig or two to the dura mater lining the cribriform fossa, and descends again into the nasal sinuses to ramify upon the Sneiderian membrane, inosculating with nasal ramuli of the internal maxillary artery.

10. *The anterior æthmoidal artery* is smaller than the posterior, and gains the nasal sinuses in company with the nasal nerve by the anterior and internal orbitar foramen. It does not, however, enter the cranium, as the nerve does, but is distributed to the lining membrane of the æthmoidal cells, anastomosing with the last described artery and the lateral nasal branches of the internal maxillary.

11. *The superior and inferior palpebral arteries.* As the ophthalmic artery proceeds towards the inner canthus of the eye, it gives off a sufficiently regular branch immediately below the pulley, which from its destination is known as the superior palpebral artery. A common trunk, however, very often gives origin to a branch to the lower as well as to the upper eyelid; in which case, it divides behind the ligament which connects the tarsal cartilages. The first branches are to the lachrymal sac, to the caruncle, and to the semi-lunar fold of the conjunctiva. The artery, or if there be two, they then gain respectively the upper and lower eyelid; they describe a somewhat tortuous course, giving a great number of branches to the orbicularis palpebrarum and ciliaris muscles, to the skin, and to the conjunctiva. From the arches which they form, a great

number of parallel and straight branches pass towards the edges of the tarsal cartilages, supplying with great freedom the Meibomean glands and conjunctival membrane. In the upper eyelid, this artery anastomoses with the frontal, nasal, suprà-orbitar, lachrymal, and sometimes with the temporal arteries; in the lower eyelid, with the nasal, angular of the facial, and infrà-orbitar of the internal maxillary artery.

12 and 13. *The frontal and nasal arteries.* We have now followed the ophthalmic trunk nearly out of the orbit, immediately prior to which point, however, it divides into its two terminal branches. The smaller of these is named the *frontal*, which, having furnished an anastomotic twig to the pulley where it meets the suprà-orbitar artery, escapes from the orbit by ascending at the side of the internal angular process of the frontal bone, turning over the brow with a corresponding nerve. It enters the corrugator supercilii, and in this muscle it divides freely and anastomoses with the suprà-orbitar and frontal branches of the temporal arteries. Some branches of the artery penetrate this muscle and the occipito-frontalis, gain the skin, and unite with branches from its fellow of the opposite side. *The nasal artery* is the true termination of the ophthalmic trunk, and leaves the orbit at its innermost edge, between the pulley and the ligament of the tarsi. It gives numerous branches to the lachrymal sac, to the caruncle, and to the tunica conjunctiva; then descending at the side of the nose, it gives, laterally, twigs to the levator labii superioris, nasal slip of the occi-

pito frontalis, and orbicularis palpebrarum muscles. Eventually it anastomoses with the angular branch of the facial artery, by a very free communication. Its ramifications join also those of the opposite side, the frontal, and suprà-orbitar arteries.

Varieties of the Ophthalmic Artery.

It is not intended to mention in this place all the varieties to which the ophthalmic artery is subject, inasmuch as both its trunk and its branches vary remarkably as to origin, number and distribution. Neither is it deemed expedient to detail the various authorities for irregularities of origin and distribution; such detail is foreign to the nature and would far exceed the limits of this work, to say nothing of its utter inutility, seeing that the vascular system presents a greater number of deviations from a standard of distribution, than any other system of which the body is composed. Neither does there appear to be any sensible difference in the function of an organ, when it receives its supply of blood from a source other than what anatomists would call the normal or regular course. Thus in the space of a very few inches, the ophthalmic artery and its branches offer numerous varieties, of which the following are some of the most remarkable; presupposing the plan already stated to be the normal distribution.

The ophthalmic artery after it has given twigs to the dura mater, within the cranium, sometimes enters the orbit *above* the optic nerve, as remarked by

Haller. Sometimes, though rarely, it penetrates by a peculiar opening, which is then always placed at the outer side of the optic foramen. The first branch which it usually gives off is *the lachrymal;* this is not, however, a constant distribution, as the lachrymal sometimes arises from the middle artery of the dura mater. In seventeen subjects, Haller found this to occur in four instances. When this variety takes place, the lachrymal branch either enters the orbit at the outer part of the sphenoid fissure, or through a foramen perforated in the ala major of the sphenoid bone. Meckel has seen an instance in which it passed *through the os malæ.*

The central artery of the retina is either given off by the ophthalmic before, or after the origin of the lachrymal, or by this latter artery itself. Sometimes, though rarely, it is furnished by the suprà-orbitar, and occasionally in common with the posterior æthmoidal.

By some anatomists, *the ciliary arteries* are divided into *superior* and *inferior*. *The long ciliary* branches, however, never divide prior to penetrating the sclerotic coat. *The anterior ciliary* are usually derived from the muscular, though frequently from any artery in the immediate neighbourhood of the fore part of the eye. *The muscular branches* are always various, but Meckel classes the suprâ-orbitar with the superior muscular, " l'artere musculaire supérieure, ou sus-orbitaire."

The posterior æthmoidal is generally the largest of the two arteries which enter the nasal sinuses, although Bichat and Sir Charles Bell contend the

contrary. It is often as large as the lachrymal itself, from which artery it sometimes takes its origin, and in that case it frequently gives off two or three short ciliary, or posterior choroidal branches. Meckel traces its ramuli to the antrum maxillare and the sphenoidal sinuses. In minute injections, where the anastmoses are so numerous, it becomes almost a matter of speculation where an artery begins or ends, as we are able to trace with ease, in any point of this intricate net-work, branches in a direction towards, or from the suspected original.

The suprà-orbitar artery is not very constant in its commencement, but its course and distribution are sufficiently regular. It emerges from the orbit and turns over the brow, either in company with the nerve, or anterior to the bony or ligamentous bridge that sometimes separates the two parts.

The anterior æthmoidal artery arises sometimes from the posterior æthmoidal, or from the suprà-orbitar artery. Its volume is variable; it never, I believe, enters the cranium like the posterior, but merely sends a few twigs to the dura mater lining the cribriform sinuses.

The palpebral branches, as already stated, either arise singly or from a common trunk. When the former happens to be the case, the superior comes off from the suprà-orbitar artery, the inferior from the nasal, or angular termination of the ophthalmic trunk. Their anastomoses constitute the "*arcus tarseus superior et inferior*." Sometimes a branch is seen coasting the margin of the tarsal cartilages, which is denominated "arteria marginalis."

The frontal and nasal arteries vary much in size; in the fœtus the former is the larger, in proportion as the cranium is at that period of life relatively so much more ample than the face. It is always one of the terminations of the ophthalmic artery.

The nasal is, occasionally, but an anastomotic twig, a descending branch of the frontal; but in the majority of instances it is the larger of the two, and sometimes it exceeds in volume the nasal branch of the facial artery, passing down as far as the alæ of the nose, of which it perforates the cartilages, and anastomoses on the lining membrane with the proper nasal arteries. It is called by some the *angular nasal artery*.

The Veins of the Orbit.

The blood which has been distributed by the branches of the ophthalmic artery is returned to the circulation by different routes; thus, that which has been supplied to the skin and muscle of the forehead is brought back by the frontal and temporal veins; from the upper and especially from the lower eyelid by the facial vein, at their nasal sides; and at their outer sides by branches of the temporal vein. The blood, however, which has circulated through the eyeball itself, and through the greater part of the orbit, is returned by the reunion of many branches into one trunk called *the ophthalmic vein*, which enters the cavernous sinus of the dura mater, the blood flowing from thence through the lateral sinus into the internal jugular vein, and so back again to the

heart. In making a table therefore of the veins, more or less belonging to the organ of vision, we have three divisions as follow:

First.	Frontal . . . Suprà-orbitar . Superior palpebral	Returning their blood by the frontal and temporal veins.
Second.	Inferior palpebral by the angular vein of the facial.	
Third.	The Muscular . Æthmoidal . . Ciliary . . . Retinal . . . and Lachrymal .	Branches returning their blood by the ophthalmic vein to the cavernous sinus.

Of the branches of the two first divisions of this table little more need be said, than that they emanate from the extreme ends of the arteries given off by the ophthalmic trunk, principally found at the inner canthus of the eye, viz. the frontal, suprà-orbitar, palpebral, and nasal. They form an intricate and tortuous net-work, which empties itself in greater part into the oculo-angular vein, which descends by the side of the nose, to form one of the origins of the great facial vein. Some of the other branches, which ramify in the upper and lower eyelids, form venous tarsal arches, that anastomose with, and terminate in the temporal veins, which last enter the internal jugular by a trunk common to them and the facial vein. In a well injected preparation, or when the face is flushed with anger or great exertion, we see very distinctly the swelling of the oculo-angular and frontal veins. Numerous anastomoses exist between these external veins of the eye, and the orbitar branches of the ophthalmic.

The Ophthalmic Vein.

Four principal trunks seem to unite near the back of the orbit to form the commencement of this vein; and these four may be divided into upper and lower, inner and outer branches. I am aware this is a very arbitrary division, but as no two subjects will furnish precisely the same distribution or arrangement, we shall be justified in giving a general outline of their course, rather than in adopting the more minute plan of some authors, who describe the various divisions of this vein in separate subjects; a plan, however creditable to the industry of the writers, presenting no other advantage to the student, than that of making him aware what was the peculiar course of the ophthalmic vein in particular cases. However irregular the ophthalmic artery may be, as is evident from the varieties given, the vein is so much more uncertain in its distribution as to make it impossible to class its deviations, and the arrangement now adopted is to be considered as entirely one of convenience, and as a comprehensive view of many dissections rather than of any particular one.

The upper branch commences by radicles from the conjunctiva, both ocular and palpebral; by ramuli from the levator palpebræ superioris and levator oculi muscle: it then passes below the last named muscle towards the back of the orbit, receives a ciliary vein, the central vein of the retina, and numerous small branches from the fat and cellular texture in its vicinity, anastomosing frequently with the lachry-

mal branch on its outer side, joining which it enters by a common trunk into the ophthalmic vein.

The outer branch arises by numerous minute ramuli from every part of the lachrymal gland, anastomosing anteriorly with branches of the superior tarsal arch and of the temporal veins. To the inner side and posteriorly it inosculates with the deep temporal vein. It receives muscular trunks from the abductor oculi muscle; anastomotic ramuli from the superior ophthalmic branch, and from the veins of the levator palpebræ superioris. It then sinks beneath the edge of the abductor oculi muscle and receives a ciliary vein: uniting then with the before described superior division, their common trunk empties itself into the ophthalmic vein. This branch may be named *the lachrymal vein.*

The lower division arises like the upper, by radicles from the conjunctiva, and the neighbouring skin and muscle of the lower eyelid. It receives veins from the inferior oblique and depressor oculi muscles, and then passes between the globe and the last named muscle, having anastomosed or received small ramuli from the infrà-orbitar vein, and those of the periosteum of the floor of the orbit, it is joined by one, sometimes by two ciliary veins, and by small twigs which ramify on the sclerotic itself. Finally, collecting veins from the fat and membrane in its immediate neighbourhood, it empties itself by a large trunk into the ophthalmic vein.

The inner division anastomoses freely, at the internal canthus of the eye, with the oculo-angular and frontal veins; it then receives branches from the

membranous sheath of the superior oblique muscles. The anterior and posterior æthmoidal veins, which are true venæ comites of the arteries of the same name, enter this inner branch. Other twigs, from the superior oblique and adductor oculi muscles, a ciliary vein, and anastomotic ramuli from the upper division, join this trunk, which finally enters the ophthalmic vein at the back of the orbit.

The ophthalmic vein, thus formed, is very short in its course, and of considerably larger volume than the artery of the same name. It is placed below and external to the optic nerve, nearly immediately under the ciliary or lenticular ganglion; it then passes directly backwards, beneath the aponeurotic origin of the muscles, penetrating the sphenoidal fissure to gain the cavernous sinus, to the outer side of the bundle of nerves which enter the orbit at this place. The ophthalmic vein sometimes escapes from the orbit in two separate trunks, which is the only variety that is worth while recording. It seems in this case to correspond to the variety, where the lachrymal artery springs from the middle meningeal artery, instead of from the ophthalmic trunk.

The Cavernous Sinus.

The cavernous sinus is so connected with the arteries, veins, and nerves of the orbit, as to demand some consideration in this place. It is to be remembered that it receives nearly all the blood that has circulated through the globe of the eye, and through

the arteries and veins of the orbit; that it gives passage to the nerves that supply the organ of vision, and its accessories; and that the carotid artery, around whose coats the ganglionic nerves are so intricately intertwined, passes through this cavity immediately prior to its giving off the ophthalmic branch. By means of this sinus there is a direct communication between the external and internal veins of the head, the ophthalmic vein being classed by Santorini as one of the "venæ emisariæ."

The cavernous sinus is of a very irregular figure, and formed like the rest of the sinuses of the dura mater by a splitting of the laminæ of this membrane. It is situated principally on the ala major of the sphenoid bone, in a hollow easily perceived in the mace rated skull. It is bounded before by the internal half of the sphenoid fissure; on the inner side by the "sella tursica;" posteriorly by the apex of the petrous portion of the temporal bone, and the cartilage which closes the foramen lacerum basis cranii in the recent subject; and externally by a line drawn through the foramina rotundum, ovale, and spinosum. The cruciform attachment of the tentorium cerebelli, to the anterior and posterior clinoid processes, and the upper lamina of the dura mater continuous with this, form its roof; while the other split portion of membrane, strongly attached to the bones already enumerated, completes the floor of this cavity. The cavernous sinus is not, however, a simple hollow like most of the other sinuses of the dura mater, but is intersected by a number of dense and reddish fibres which gives it a cellular aspect or cavernous struc-

ture, whence its name. Much doubt and controversy has arisen as to the nature of these fibres; by some asserted to be nervous, by others fibrous membranes, and lastly by some, to be vascular. It is probable that they may be composed of each and all; since in a well injected subject some small arteries may be discovered amongst them, somewhat analogous to the "rete mirabile" found at this spot in certain animals; while on the other hand, the intricate anastomoses of the ganglionic nerves may furnish some few fibrillæ to the dura mater and cellular laminæ intersecting this cavity.

The communications of this sinus with emisary veins and other sinuses of the dura mater are very numerous; they are as follows:—Anteriorly, the ophthalmic and some small veins, which enter by the sphenoidal fissure, empty themselves into the cavernous cavity, is also the "vena sodalis arteriæ carotidæ internæ." On the inner side it communicates with the circular sinus. At the posterior part, with the basilar, superior and inferior petrosal; and with its fellow of the opposite side by the transverse sinuses. Besides these it receives some meningeal veins, and others, from the anterior lobes of the brain and fossa Sylvii.

Of those nerves that pass through the cavernous sinus some account will be given, and it will therefore be sufficient in this place to say, that on its outer side is situated the semilunar ganglion, with the first division of the fifth pair anteriorly, and the third, fourth, and sixth pair. These nerves are separated from the blood of the cavity, by thin membranous

septa, excepting perhaps the sixth pair, whose covering, if any, is exceedingly thin and transparent: the carotid artery, surrounded by ganglionic filaments, passes through this sinus, invested also with a cellular sheath.

Vicq. d'Azyr explains, satisfactorily at least to himself, the critical hæmorrhages from the nose, that take place occasionally in fever, on the ground of the communication of the ophthalmic vein and the cavernous sinus, it being remembered that the anterior and posterior æthmoidal veins are branches of the ophthalmic trunk.

OF THE NERVES OF THE ORBIT.

The orbit contains several pair of nerves exercising distinct functions, all more or less connected with the organ of vision. Of these, four pair are exclusively, and one pair partially subservient to this function. One set conveys sensation to the globe of the eye; another communicates voluntary motion; a third is of mixed character; whilst a ganglion is present which involves all the mysteries of organic life; and lastly, a pair peculiar to the globe of the eye, the nerves of actual vision. In order to facilitate the description of these intricate structures, which involve so many interesting physiological phenomena, we shall arrange them on a plan adopted rather according to their importance, than to their numerical order. The following is proposed as a table of the nerves of the orbit.

Nerves of the Orbit.	2nd pair, or Optic nerves. 3rd pair, or nerves of voluntary motion, common to most of the muscles. 4th pair, voluntary nerve, proper to the superior oblique muscle. 6th pair, proper to the external straight muscle, also a voluntary nerve. 5th pair, first division of, which communicate sensations to the eye and contents of the orbit. Lenticular ganglion and its communications.

Optic Nerves.

In the first section of this treatise, the origin, course, and termination of the optic nerve is described. It will be unnecessary, therefore, to do more in this place, than to give a brief summary of its anatomical relations, in order to connect this portion of the subject with the nerves of the orbit generally.

The optic nerve has been described as originating in the retina, where it is gathered together in a round cord at the posterior and inner part of the sclerotic coat; in other words, it emerges from the globe of the eye a little to the inner side of its axis, and in the central line relative to the height of the globe. From thence to the optic foramen it takes a tortuous course, being somewhat longer than the line it traverses between these two points, in order to facilitate the various movements of the eye, without the nerve being subject to tension or pressure. The two nerves having entered the cranium, converge, and shortly

meet in the space between the two anterior clinoid processes above, and immediately before the fossa that receives the pituitary gland. For a short space both nerves seem to be blended and compressed into a sort of rhomboidal mass, from the posterior edge of which mass they again emerge, no longer round as heretofore, but in a flattened form. After diverging for a short distance, they wind round the crura cerebri in the line called "tractus opticus", and are at length blended with the posterior part of the cerebrum, immediately anterior to the valve of Vieussens. In their passage from the point where they unite, called the commissure of the optic nerves, they are in constant communication with the different masses of grey matter they meet with at the base of the brain, either giving fibres, or receiving them from the tuber cinereum. For reasons previously stated it is probable that the nerves furnish filaments to this point, as from this spot it is evident that they are sensibly diminished in size. During the whole course of the tractus opticus, the nerves are in constant relation with the fibres of the inferior parts of the middle lobes of the brain, by a succession of minute fibrilla. Proceeding posteriorly they spread out into medullary planes adherent to the posterior part of the thalami optici, giving fibres to the corpora geniculata, externa and interna, and eventually terminating by intimate union with the corpora quadrigemina, especially with the posterior pair. These nerves are not only in close connection with each other, at the anterior part of their course, but they are also brought into reciprocal and intimate relation

in several different ways. Of these the most obvious one is by the posterior commissure of the brain, and the transverse fibres that join the corpora quadrigemina. The anterior commissure of the brain, by accurate dissection, shews the connection subsisting between the fibres of the superior part of the anterior, and the fore part of the middle lobe of the brain of either side, thus indirectly uniting the optic nerves.

In relation to the question of the commissures, although the subject is in its nature exclusively physiological, I cannot resist the opportunity it presents, of submitting a few observations on certainly one of the most interesting phenomena appertaining to the sense of sight; viz. single vision, as exhibited in the fact, that only one picture or image of external objects is impressed upon the brain, although we are possessed of two separate and equally perfect organs of sight, I am aware that in a work avowedly anatomical, it may seem to be travelling unnecessarily out of the direct path to introduce a subject essentially connected with the *theory* of vision. My apology is to be found in the curious nature and deep interest of the enquiry, replete with intricacies and difficulties of no ordinary weight, and at the present time but imperfectly understood.

I have already, in another place, asserted an opinion, that the origin of certain nerves ought to be placed at the periphery of the particular organ, over whose functions they preside; whilst the origin of certain other nerves might with propriety be placed in the brain itself. To the former class the nerves of sensation belong; to the latter, the nerves of

volition. The first class appear to terminate in the brain; but considerable distinction is to be made in relation to the mode, in which the termination is ultimately effected in the different kinds of nerves of sensation. Of the five several senses, properly so called, three of them possess double sets of organs, with single mental perceptions, and this phenomenon of *concentration* is produced, as I conceive, simply and solely by the agency of the commissures. The impressions conveyed to the brain are involuntary, or, at the utmost, only partially under the control of the will; in strict fact produced by the nerves proceeding from the organs of these senses. The three senses, *seeing*, *hearing*, and *smelling*, which with each a two-fold external apparatus produce a single perception, may be called *the concentrated senses*. The other two, *taste*, and *touch or feeling*, may be denominated *diffused*. The last indeed seems to be distributed over nearly the whole surface of the body; and is capable of being exercised over several points at one and the same instant, and of effecting one or more perceptions. In each of the first class, the concentration is not equally perfect; but in the organ of sight the function is decisive and complete. Here we find an apparatus placed at either side of the mesial line, performing separately the self same functions, both stimulated by the same rays of light, and both giving to the retina the same picture or impression; this picture or impression is conveyed, with equal precision, by each nerve to the brain, where it becomes concentrated, or condensed as it were, so as ultimately to produce one only perception.

The external impression being transmitted to the sensorium with equal perfection at either side, the brain also being symetrical; it follows of course, that one side of this organ is capable of exercising its functions in perfection, as well as the other side. In this case, then, behold two distinct pictures or impressions of one and the same object, presented to two separate percipient organs! Whence comes it, therefore, that we are not sensible of a two-fold perception? Is not the explanation to be sought for, and may it not be found in the commissures?

It has been supposed, that two pictures are actually presented to the brain, and that the inconvenience which would ensue is corrected by education, in the same manner, that the inverted position of the image impressed upon the retina has been supposed to be rectified by the force of habit. This hypothesis has been disproved by the facts observed in cases of congenital cataracts, cured at an advanced period of life.

Recollecting what has heretofore been stated respecting the anatomy of the optic nerve, it might be inferred that the actual junction of the two nerves, at the processus olivaris of the sphenoid bone, constitutes the actual commissure of concentration; but these nerves, in their subsequent course, again diverge and pursue each a distinct and separate passage to the brain; so may each nerve, be presumed to continue to carry a separate, yet similar impression to the percipient organ. Let us advert then, to the actual termination of the nerve, and here we may

observe distinct transverse bundles bringing into relation with each other the opposite, though symetrical sides of the brain, that receive the ultimate and terminal fibres of the nerves.

Under certain circumstances of functional disorder, a two-fold perception, or double vision occurs, and these cases often prove highly instructive in our endeavours to follow out this interesting subject.

In certain unnatural or unhealthy states of various organs, as in dyspepsia, or where the sensorium has been overstrained by undue tension, or by an excessive indulgence in the use of intoxicating liquors, instances of double vision not unfrequently occur. Now, as under similar circumstances, it is well known that other functions of the brain, as the sense of hearing, the power of voluntary motion, the judgement, &c. are also troubled and impaired, why, it may be asked, should the commissures of the optic nerves alone be excepted from the general disturbance?

I am not aware of any congenital case of double vision, where the disorder may not be accounted for by the existence of some actual physical imperfection of the eye. In certain cases of palsy of the third pair of nerves, the eye is distorted outwards by the action of the abductor muscle, and double vision ensues. Or, if one eye be distorted from exact parallelism with the other eye, an effect that may be produced by artificial means, the same phenomenon occurs, and will at once be recognised, as arising out of an altered condition of the axis of the two eyes. The images in this case do not correspond, or in

other words, and more correctly speaking, the eyes are not impressed by similar objects on similar relative portions of their recipient surfaces; a state resulting from each eye not being directed to the same point, or not acting in accordance with its fellow organ. In cases of confirmed strabismus, however, double vision does not take place; the distorted eye being generally deficient in focal power, as compared with the organ of the sound side. In this state, the healthy and perfect eye may be said to have the force of habit on its side, and by this force neutralizes or even overpowers the impression made by the other and morbid eye. In other words, the sensorium does not perceive or recognize the weaker stimulus, and rolls the feebler organ out of the line of direct vision, in order to prevent its interference with the picture produced by the sound and stronger instrument. The eye, which in this case is rolled inwards towards the nose, is thus placed by the involuntary action of the inferior oblique; the voluntary muscles ceasing to exert their influence over an organ, whose function is not only not required to be exerted, but which would only produce confusion and inconvenience.

The position here advanced is materially strengthened by reference to the organ of hearing, the anatomy of which, exhibits the junction or union of the terminal fibres of the auditory nerve upon the floor of the fourth ventricle in the cerebellum, where by a similar commissure, a similar perceptiveness of impression takes place.

In the organ of hearing, a loud noise overpowers a weaker sound, which is therefore lost to the sense and not perceived or heard. Sir Charles Bell hints at the analogy subsisting between the organs of sight and hearing in this respect, while quoting two cases of double hearing reported by Sauvages. Of these cases I beg leave to introduce the second. "Very lately, a foreigner came for advice in a similar situation (double hearing). He complained, that when any person spoke to him, he heard the proper sound of the voice, and at the same time another sound accompanying it an octave higher, and almost intolerable to him; as it must have happened, if the accompanying sound had preserved the true octave above the voice, and been synchronous with it, the ear would have received them as one sound, and have been pleased with their concord, it is probable that the accompanying sound was not in unison with the true." (Sauvages, Vol. III. p. 352). The author in the preceding case supposes that the natural tone of one of the ears was altered, and that the sound appeared dissonant, so that one of the ears being weakened or otherwise altered by disease, no longer transmitted to the percipient part of the brain a sound corresponding with that of the healthy side. The commissures, therefore, could not perform their accustomed office of recognising and blending similar sounds or similar degrees of tone; thus an effect was produced like that which takes place in non-accordance of the axis of vision, or as if two distinct sounds, differing in key and intensity, had been

offered in regard to the sense of hearing, or two different pictures or images had been presented to the brain, in reference to the organ of sight.

The Third Pair of Nerves

The nerves destined to preside over the movements of the eyeball, are derived from three distinct pairs or sets; viz., the third, fourth, and sixth. The two latter being distributed to the superior oblique, and to the external straight muscles respectively; the third pair, to all the remaining muscles: in consequence the third pair, in the order of their succession, are named the common oculo-motors. They arise from the brain, and pass, together with several other orbitar nerves, during a certain space, through that cleft or division of the layers of the dura mater called the cavernous sinus. They enter the orbit through the superior lacerated opening, subdividing in order to supply the levator palpebræ superioris, the superior, internal, and inferior straight muscles, and the inferior oblique; which latter receives an involuntary power, in consequence of the connection of the branch of the third pair, which supplies it with a filament from the lenticular ganglion.

Before the origin, progress, and final distribution of the third pair of nerves, be stated in detail, it may be observed, that, as the method of enumerating the nerves emanating from the brain is altogether arbitrary in its character, we may expect to find

among the earlier writers on the subject, many and various appellations given to these parts. In an English work on Anatomy by Dr. Reid, published in the reign of Charles the First, we have a short and curiously imperfect account of the nerves, or as the author calls them, of "the sinews of the brain."

"Optica prima, oculos movet altera, tertia gustat."* Thus this second pair or movers of the eye, correspond to the third pair, with this exception,—that Dr. Reid does not trace them to the levator palpebræ muscle. The third pair in this classification, is the same with our fifth pair, to which, however, he joins the fourth, a branch being assigned to the superior oblique muscle. The sixth nerve is altogether excluded, so that the levator of the eyelid and abductor oculi muscles, according to Dr. Reid, are entirely devoid of nervous supply and power. Vesalius believed that the fourth pair, were accessory to *his* third pair, and he called them "rami graciliores tertii." This error was corrected by Fallopius, who furnished a more accurate description of the "motores oculorum communes." The successive improvements of Willis, of Vieussens, Valsalva, and Winslow, with the more recent descriptions of Cloquet, Meckel, Spurzheim, and Swan, leave us nothing further to desire upon this point.

The third pair of nerves, are the first in the order of voluntary muscular nerves; they arise from the tract corresponding to, and in fact the continuation

* Dr. Read agrees in the classification of Vesalius.

of, the anterior cords of the spinal marrow. More minutely traced they commence by a number of delicate filaments from the inner edge of the crura cerebri, between the corpora albicantia and the anterior margin of the pons Varolii. At this point their texture is very soft and delicate, and they break with great facility; but by gentle management they may be traced under the pons Varolii, to the central black spot (locus niger) of the crura cerebri. From this origin the various and scattered fibres are collected into a slightly flattened bundle, which soon acquires a firmer consistence, each fasciculus being covered by a fine membrane, and the entire cord invested with a true neurilema. The posterior cerebral and superior cerebellar arteries hook round the origin of this nerve, which now advances forwards, along the inner and inferior edge of the middle lobe of the brain, as far as the anterior attachment of the tentorium cerebelli; where it loses its arachnoid covering, and enters the cavernous sinus.

So far as this point the nerve is about one-ninth of an inch in thickness, and in length about six-eighths of an inch: in point of size, it holds a middle place between the optic and fourth nerve, or pathetic. In the first part of its passage, through the cavernous sinus, the third nerve is placed to the inner side, and above the level of the fourth, and of the ophthalmic division of the fifth pair of nerves. Near the anterior clinoid process, however, and shortly before it enters the orbit, the two last-named nerves ascend, and pursue a course obliquely and internally to the common oculo-motor.

A short distance before the third nerve escapes from the sinus, it divides into two distinct branches, one above the other, and thus enters the orbit at the most ample part of the superior lacerated opening, in company with the nasal branch of the ophthalmic division of the fifth, and with the sixth nerve, to which it is united by fine cellular tissue. In combination with these latter nerves, it passes between the origins of the external straight muscle, and divides in the following manner:—

The superior branch, passes forwards, and obliquely inwards, above the optic and nasal nerves; then proceeding to the ocular aspect of the superior straight muscle, it supplies to it many branches, anastomosing with some of the nasal twigs of the fifth pair of nerves. The remaining filaments of this branch are distributed to the levator palpebræ superioris muscle.

The inferior branch, of greater size than the former, passes downwards and forwards, between the outer and inferior edge of the optic nerve and the depressor oculi muscle; it divides into three distinct branches, of which the first and shortest enters at once into the depressor muscle, to which it is distributed by numerous ramifications. The internal, or larger division, passes obliquely to the inner side, beneath the optic nerve, and is supplied to the substance of the adductor oculi muscle. The external division is by far the longest, and at the distance of about a line from the point where it separates from the others it receives a twig from the lenticular ganglion. This connection is remarkable, as it seems to furnish, to a certain extent, an involuntary action

to the muscle which this filament supplies; as previously observed, when treating of the action of the oblique muscles. The external branch then, with this addition, passes between the inferior and external straight muscles, without furnishing any branch: it proceeds for some lines beneath the globe of the eye, finally entering, at nearly a right angle, the inferior oblique muscle, at a short distance from the commencement of its tendon; to the fleshy part of this muscle it is entirely distributed.

The third pair of nerves gives voluntary motion to all the muscles of the eye, except the superior oblique and the abductor; and probably a mixed, or involuntary kind of action to the inferior oblique, by reason of its connection with the sympathetic system of nerves.

The Fourth Pair of Nerves.

The fourth nerve, is destined solely to the superior oblique muscle of the eye. It is the "radix gracilior tertii paris" of the ancients. Fallopius was not far from the truth, when he represented it as a distinct nerve, and derived it from the corpora quadrigemina. Eustachius and Santorini, however, more accurately assigned its origin to the transverse tract *behind* these bodies. Soëmmering describes its origin, indifferently, from the posterior pair of the corpora quadrigemina, or from the valve of Vieussens. Sir Charles Bell associates the roots of this nerve with those of the seventh or facial nerves, and includes it amongst the assistant respiratory nerves.

The fourth pair of nerves are the longest, and most slender of all the cerebral nerves. They arise by three or four roots from the lateral parts of the valve of Vieussens, immediately behind the posterior pair of the corpora quadrigemina. The upper or anterior roots appear sometimes to join, or anastomose with those of the opposite side. The posterior filaments arise somewhat nearer to the cerebellum, and are connected with the lateral pillars uniting the cerebellum with the brain. The number of roots vary from two to five, sometimes of unequal number at the different sides. These roots are then collected into one body, and the nerve separates from the valve, and in the first instance, passes forwards, downwards, and outwards, round the processus à cerebello ad testes; subsequently, anteriorly around the crus cerebelli, here placed immediately above the superior artery of the cerebellum: it then proceeds forwards, and after a course of about one inch and a half in length from its commencement, it enters the cavernous sinus.

When the fourth nerve first separates from the valve of Vieussens, its texture is extremely soft and fragile; it does not seem to be invested, or, to speak more strictly, to be intersected with pia mater; so that, by Dr. Gordon, it is considered to be without either filaments, or fasciculi. In the course of its passage through the interior of the cranium, this nerve is nowhere above the fortieth part of an inch in thickness; but its figure is round, and its texture becomes firmer, and more resistant than at the earlier part of its course, being here strengthened by the arachnoid

membrane. The nerve next proceeds along the smaller circumference of the tentorium cerebelli, to enter the cavernous sinus opposite to the posterior clinoid processes. In this cavity it is first placed at the outer side, separated by a thin cellular plate, from the third nerve, which is placed above and to the inner side of the fourth. In its progress forwards, its relative position becomes changed: about half way through the cavernous sinus, it takes an upward course, ascending at the inner side of the common oculo-motor nerve, accompanied by the frontal division of the fifth pair of nerves, with which it enters the orbit by the superior lacerated opening. Here, divested of its arachnoid covering, it is seen placed above the origins of the levator oculi, and levator palpebræ superioris muscles, and beneath the periosteum of the roof of the orbit. Having somewhat increased in size, it proceeds obliquely inwards, reaching the belly of the superior oblique muscle, in which it is eventually expended. Throughout its entire course, it is said not to give off a single branch, or even an anastomotic twig; an assertion, however, that may be questioned; for in some recent dissections, I certainly have observed a junction or union by anastomosis, not only between the nerve in question and the lachrymal branch of the fifth pair of nerves, but also between it and some of the smaller filaments of the sympathetic plexus, that intertwine around the internal carotid artery in its passage through the cavernous sinus. The fourth pair of nerves are also called "the pathetic," from their expressing through the agency of the superior oblique muscles, the passions of love or pity.

Sir Charles Bell, unless I much misunderstand the passage at page 213 of his 4to volume on the Nervous System (1830), beginning, "the expression of the eye in passion," associates this nerve with the nerves of respiration, and consequently with those of expression. But is it necessary that all respiratory nerves should peculiarly preside over expressions, and *vice versâ?* Since all the nerves of the eye, which have any power over its movements, even to the motions of the iris, are equally expressive of certain passions, without the necessity of shewing them to be connected with respiratory action. Thus Gall and Spurzheim remark, "Every nerve subordinate to the brain can be put in action as an instrument of the passions, but independently of the brain, no nerve is the organ of any sentiment whatever; the expression of anger, love, pity, or pride, &c. is not attached to this or that position of the eye, but to the general disposition of the features produced by the affections or passions."

It is right, however, to state with reference to the association of the roots of the fourth and seventh pair of nerves, that Sir Charles Bell, although unquestionably the best English anatomist and observer of these very interesting subjects, does not consider the point as absolutely demonstrated, and states the case with great candour. "I must confess that the point of anatomy is still a desideratum. I have not in a manner satisfactory to myself, made out the relation between the roots of the portio dura and fourth nerve." (Ibid. p. 213.)

The Sixth pair of Nerves.

The history of the sixth nerve has partaken of that obscurity and error in which a large proportion of the cerebral nerves has been involved. Thus, when Vesalius classed the fourth pair, as the " minor propago tertii paris" (the same with our fifth), so he also described the sixth nerve, as " a branch of his second " or our common oculo-motor nerve. Fallopius commencing with the optic nerves, names this sixth as the fourth nerve. Since the time of Willis, anatomists have been pretty well agreed as to the numerical classification and arrangement of the several nerves ; and although on the present occasion, in the description of the nerves of the orbit, some deviation from such arrangement, in favour of the more natural order of function, may be remarked, still old and established terms have been respected, and on all reasonable occasions have been retained.

Respecting the origin of the sixth nerve much difference of opinion has arisen. The distinctive appellations given to it, by the more ancient writers, sufficiently mark the errors into which some of them have fallen: but even among anatomists of high name, and of periods not remote, much variety and discrepancy of opinion are apparent. Vieussens, Morgagni, Winslow, Vicq. d'Azyr, and Sabatier, all differ in their respective relations of its origin. That there may be varieties and peculiarities of origin in various subjects is indisputable; and in the writings of these very authors, we have abundant proof, that the actual

number and position of the primary fibres of the sixth nerve do, occasionally, vary at the two sides of the body, even in the same individual person; that this nerve, at its commencement, presents a double or two-fold appearance; and that this variety may, in some cases, occur at one side only, without authorizing the conclusion, that any notable or important functional difference is necessarily connected with, or resulting from the fact in question. It has never yet happened to me, however, to observe the sixth nerve, out of its established line of succession, or distributed to other structures, than those hereafter to be described—in this respect differing, in a sufficiently marked manner, from the vascular system, in which a large variety of anatomical distribution occurs. Indeed the order and arrangement of the nerves is nearly always uniform; and probably this very uniformity has given rise to the observation and description of the very rare varieties in question by the great names above mentioned.

The sixth nerve arises by several fibres (which Vicq. d'Azyr, and other French, and some German authors of our own day, consider as separate and distinct origins), from the line between the pons Varolii and the medulla oblongata. These fibres are commonly to be perceived at the side of the processus pyramidalis, and close to the mesial line. Whether separated into distinct roots, or otherwise, they are observed to be speedily collected into a single bundle, holding in respect to size and substance, an intermediate place between the third and fourth pair of nerves. In some instances the sixth nerve

appears to arise directly from the pons Varolii itself; a little dissection will, however, soon correct this error, and show, this is not the true and real source whence it derives its origin, but that at this point it is crossed and concealed by one of the transverse bands of the pons Varolii. Meckel has observed cases in which an origin by two distinct roots does actually occur, and proceeding onwards, their fibres do even enter the cavernous sinus in distinct and separate fasciculi; a disposition which he has remarked solely at the left side of the body. An example of this variety I have had an opportunity of observing at both sides in the same subject. Whenever the two roots of this nerve are truly and perfectly distinct, that which is situated at the inner side, or nearest to the mesial line, has, almost invariably, been found to be the smaller one.

The sixth nerve, then, arising from the processus pyramidalis of the medulla oblongata, proceeds forwards and somewhat downwards towards the lower part of the sphenoid bone. It then passes, first, under the posterior clinoid process, where it throws off its arachnoid covering by which it had hitherto been invested, and enters the cavernous sinus. Here proceeding in close contact with the internal carotid artery, to which it is indirectly attached by loose cellular membrane, and separated by a very thin cellular septum from the blood of the cavernous sinus, it finally enters the orbit by the superior lacerated opening. Whilst yet in the cavernous sinus, the nerve receives from the superior cervical ganglion one or two small branches or twigs, that enter

the cranium by the carotid canal. These twigs, which previously surrounded the internal carotid artery, are soft in their texture and of a pale red colour; they unite with a branch of the fifth pair of nerves called the recurrent pterygoideal, forming an intricate plexus surrounding the artery, and communicating by other minute filaments with almost every nerve contained in the sinus. In the older language of anatomy, this union of the sixth nerve with the recurrent pterygoideal nerve is described as the origin of the sympathetic; a term probably totally misapplied. In point of fact it is now nearly, if not completely established, that the various communications of the nerves of organic life with those of the cerebral and spinal nerves are effected by filaments sent off from the different ganglia, as centres of a new influence, and probably to associate separate nerves to combined action.

Emerging from the cranium by the lacerated opening, the sixth nerve, accompanied by the third and nasal branch of the fifth nerves, enters the orbit between the two origins of the external straight muscle. It speedily separates, however, and reaching the ocular surface of the abductor muscle, it enters it at the posterior portion, and distributes its filament to the fleshy fibres of this muscle alone. Previous to this, it sometimes anastomoses with the nasal branch of the fifth nerve, and with twigs from the lenticular ganglion.

Its action is to give power to the external straight muscle of the eye, and hence has been called the *external motor nerve.*

The fifth pair of Nerves.

This curious nerve, or bundle of nerves, by the apparent intricacy of its distribution and connections, has deeply engaged the attention of anatomists; and as usual much variety of opinion has arisen, and long and animated discussions as to its ultimate connection with the brain, its actual distribution and functions, have been excited. This subject, so replete with interest, has been duly considered and largely debated in the several works of Santorini, Wrisberg, Meckel, Gall and Spurzheim, Rolando, Cuvier, Serres, and Majendie. For nearly all that is really important in these points we are mainly indebted to Sir Charles Bell, who has greatly facilitated the study of the anatomy of this nerve by his numerous experiments, and observations on its respective functions.

It may in the first place be observed, that at its entrance into the cavernous sinus, and before its division into its large branches, the fifth nerve is furnished with a ganglion of considerable size; and that a certain set of fibres, whiter in colour, and denser in texture than the others, are not engaged, nor directly connected with this same ganglion, but that they pass beneath it without actual union or anastomosis.

In this respect the fifth nerve bears a general resemblance to the spinal nerves; and led by the observation of this circumstance, Sir Charles Bell confirmed this relation, by establishing by direct experiment a similarity of function. Thus the gan-

glionic branches were proved to belong to the sense of touch and feeling, whilst the separate and distinct plan of fibres presided over motion, and belonged to the class of voluntary nerves. To this remark it may be added, that one parcel of the fibres of the ophthalmic division of the fifth nerve appear to belong to the function of secretion. Hence we have a triple nerve appropriated in common to the senses, to voluntary muscular power, and lastly to the purposes of organic life, directly connected with the secretion of the lachrymal fluid or tears.

It will shortly be seen how far the anatomical arrangement of the fifth pair corresponds to its destination, and to the performance of its different and distinct functions. For the sake of perspicuity of description, the question as to whether the sensitive fibres of the fifth nerve do arise from the periphery of the forehead and face, as asserted by Serres, must be suspended, and the ordinary course of tracing it *from* the brain will be adopted in the following description.

Placing the basis of the brain upwards, *the fifth nerve* is first seen emerging, as it were, from that point of the pons Varolii, where the crura cerebelli may be said to join this transverse band of medullary fibres. Its first appearance is in the form of a soft white button, from which immediately succeed numerous compact fibrils, each enclosed in a separate neurilema. Of these fibres some of them are of firmer texture than others; in most instances a very slight degree of force is sufficient to sever them from this medullary prominence, leaving still connected that

particular bundle heretofore mentioned, as not passing into or uniting with the ganglion attached to the rest of the fibres. It often happens, however, that this last bundle appears separate and distinct from its very commencement, as it leaves the pons Varolii, divided from the rest of the nerve by one of those transverse bands of which the pons Varolii is composed, or in the words of Wrisberg, "Lingula quædam pontis intercedens inter has portiones." This is sooner or later gathered into the general mass, and though easily to be distinguished and followed, is still invested with the general membranous covering. In this form it proceeds to the opening, by which it penetrates the dura mater into the cavernous sinus.

If we trace the fibres of this nerve deeper into the white matter of the pons Varolii, we shall find a separate and distinct tract taken by each of the bundles already mentioned. If for the sake of distinctness we call the ganglionic portion of the nerve, the lateral, and the other the anterior roots of the fifth nerve, we may, in a brain favourable to this purpose, trace the latter through the pons Varolii as far as the anterior pillars of the medulla oblongata; though in some instances, not further than that line of longitudinal fibres proceeding from the corpora pyramidalia to form or join the crura cerebri. The lateral roots take the direction of the crura cerebelli, and they have been seen to proceed as far as the corpus denticulatum found in the medullary centre of the crus cerebelli. M. Serres in his work on the Comparative Anatomy of the Brain, tracing the anterior roots in a fœtal brain, prior to the formation of the pons

Varolii, says, "Il rencontrai les racines antérieures des nerfs trijumeaux sur les côtés des pyramides antérieures; elles étaient adossées à la partie qui correspond au-dessus de la place des olives; elles adhéraient ensuite à la partie latérale de la moelle allongée." With regard to the posterior roots the same author observes "Leur implantation a lieu sur les parties laterales du pédoncle du cervelet; ils me paraissent correspondre aux faisceaux postérieurs des nerfs rachidiens." (Vol. I., 370 to 374).

From these origins or terminations, for strictly speaking they are both the one and the other, may be traced the nerve composed of many filaments, and, in a flattened shape, proceeding towards the superior extremity of the petrous portion of the temporal bone, where the arachnoid membrane being reflected, the nerve enters the cavernous sinus by perforating the dura mater. This is effected in a direction obliquely outwards, so that the internal and anterior edge of the nerve is longer, by about two lines, than its external and posterior; the total length of the nerve from its disengagement from the brain to its entry into the cavernous sinus is about half an inch; its breadth about three lines.

In the cavernous sinus it assumes a very different shape, bearing some resemblance to the webbed foot of a duck: it becomes flat and extended. Its filaments at first are disgregated, then intricately plexiform; bathed in a thin serum, and mingled with a dense reddish fleshy body, which by its intimate interlacement with the fibres of the nerve forms the ganglion semilunare, or ganglion Casserii. It is cres-

cent-shaped, with its convexity looking forwards and outwards. No fibres can be traced through the ganglion entire, but beyond it they are again collected into trunks, which pursue their respective courses in three different directions.

Such is the appearance of the fifth nerve at its upper surface; but if it be raised from its bed, a bundle of white fibres, firm and of compact texture, may be observed, that do not intermingle with the ganglion, but loosely connected by cellular and fibrous tissue, pursues a course independent of it, towards the most posterior and external of the openings (foramen ovale), by which it makes its escape from the cranium, accompanied by a ganglionic portion of the same nerve. The only portion, whose destination it is our province to describe, is that which constitutes the anterior or ophthalmic division of the nerve, which passes into the orbit to supply the contents of this cavity, the nose, the skin of the eyelids, forehead, and contiguous structures.

Previous however to quitting the subject of the ganglion, it ought to be observed, that the dura mater is firmly adherent throughout the whole extent of its surface, and that too by so many minute fibrous threads, as to leave anatomists in doubt, whether this membrane receives at this part any branches from the fifth nerve. Probably it does receive some; but as there is no direct or demonstrative proof of the fact, for the present at least nothing conclusive upon the subject can be advanced.

The anterior division of the Fifth Nerve.

The ophthalmic division of this nerve, composed of several parallel fibres, passes off from the most anterior part of the semilunar ganglion, and proceeds along the external edge of the cavernous sinus. The nerve here divides into two portions, each, in the first place, external to and above the sixth nerve, which they cross: the inner and larger portion, then rising above the third nerve, and passing along obliquely upwards and inwards, reaches the outer side of the fourth nerve, and enters the orbit accompanied by it. The outer portion of the ophthalmic division pursues, during a short space, its original direction, and divides into the nasal and lachrymal branches: the former and larger passes upwards and inwards, and, accompanied by the third and sixth nerves, enters the orbit.

The lachrymal nerve enters the orbit alone, and most externally of all the orbitar nerves.

The ophthalmic division, prior to its separation into three portions, receives whilst yet in the first part of its course through the cavernous sinus, one or more filaments from the sympathetic nerves, that twine around the internal carotid artery. These filaments, indeed, from the peculiarities presented by this class of nerves, it is exceedingly difficult to trace distinctly along the course of the ophthalmic; but there is reason for concluding that they are actually prolonged into the lachrymal nerve.

Meckel has described an anastomosis between the

sympathetic and the fifth nerves, prior to the commencement of the semilunar ganglion. In a recent dissection of the nerves of the cavernous sinus, I observed a distribution completely corroborative of the description given by Sir Charles Bell of the various junctions of the fifth nerve with the other orbitar nerves, either directly or through the medium of the sympathetic system. In the particular instance, which I had an opportunity of observing, a small twig of the sympathetic nerve, that ramified on the coat of the internal carotid artery, after repeatedly dividing and joining the sixth nerve, united with the ophthalmic branch of the fifth ; it then passed off and joined the fourth nerve. Still further on, the nasal branch of the fifth formed an anastomosis with the third. The same sympathetic twig, which had formed the medium of these various communications, passed beneath a small fibrous band, or sort of bridge in the cavernous sinus adherent to the pituitary gland, and penetrating the dura mater posteriorly, entered the cavity of the cranium. As the brain had been previously removed, I had no opportunity of tracing its further communications. Perhaps it might have joined the ganglion situated on the communicating branch of the two anterior cerebral arteries.

The Frontal Nerve.

The frontal nerve is larger than either the lachrymal or the nasal branches, and it enters the orbit by the superior lacerated opening, accompanied by and

closely adherent to the fourth nerve. After it has escaped from the cavernous sinus, we find it placed beneath the periosteum of the root of the orbit, at the outer side of the superior straight muscle of the eye, and the levator palpebræ superioris. It then passes forwards, lying upon the last named muscle, and divides speedily into two branches, sometimes of equal size, but generally the outermost of the two is the larger.

The external frontal branch having reached the great anterior opening of the orbit, passes out by the superciliary notch or foramen; if by the former, it is protected by a ligament, which, in the recent subject, converts the notch into a foramen. At this part of its course it gives off a minute filament, that pierces the bone to gain the frontal sinus, where its divisions are distributed upon the membrane lining this cavity. The principal trunk, emerging from the orbit, goes directly to the forehead, giving off branches at the inner side to anastomose with the internal frontal nerve; and some filaments externally, to join, in the skin and muscular structure of the upper eyelid, with divisions of the lachrymal and facial nerves. It now separates into two divisions, superficial and deep. The former penetrates the corrugator supercilii and occipito-frontalis muscles, to each of which it sends filaments anastomosing with the facial nerve. Having reached the skin of the forehead, it pursues a course directly backwards to anastomose at the very vertex with the occipital nerve. In this tract the nerve frequently subdivides and unites with itself; but its general direction is

radiating from the notch to expand in the skin of the upper part of the head. Some anatomists have asserted the presence of its ultimate fibrillæ in the roots of the hairs.

The deep branch divides into shorter filaments than the superficial, which are principally expended in the muscles of the brow and skin of the forehead, and even of the root of the nose. All these branches will appear, more or less numerous, according to the skill and patience of the dissector employed in the exhibition of them.

The internal branch of the frontal nerve, or as it is sometimes called, the nervus super-trochlearis, proceeds, after its separation from the main trunk of the frontal nerve, forwards and obliquely inwards, towards the cartilaginous pulley of the superior oblique muscle of the eye, where it may be seen lying at its outer side. Here it gives off a branch, that anastomoses by arch with the anterior filaments of the nasal nerve, sending thence other filaments to the caruncle, and lachrymal sac. The remaining branches, of larger size, pass out of the orbit by a notch seen in its superciliary line, immediately anterior to the pulley of the superior oblique muscle; having reached the muscle and skin of the brow and forehead, it subdivides in the following manner:—The innermost of its filaments are expended in the substance of the corrugator supercilii muscle; the middle and larger branches pass through this muscle to the occipito-frontalis, and supply the skin of the forehead at the inner side up to the median line: they anastomose with each other, but not with the

corresponding nerves of the opposite side: lastly, the outermost filaments anastomose with the facial, and fibrillæ of the outer or proper frontal nerve.

The Nasal Nerve.

The nasal nerve, in its passage along the cavernous sinus, receives a minute branch from the sympathetic nerves, which is either wholly confounded in it, or, after a short and partial union separates from it, and enters the orbit to gain the lenticular ganglion. In the ordinary language of anatomy, the nasal nerve is represented as sending off a filament while in the sinus, and with it proceding to join the lenticular ganglion soon after its entrance in the orbit: at all events there is a very distinct communication between the ganglion and the nasal nerve, and which may be said to form its first obvious anastomosis. The nasal nerve, now united with the third and sixth nerves by cellular tissue, enters the orbit, by the sphenoid fissure or superior lacerated opening, above the two last named nerves, and between the double origin of the external straight muscle of the eye. Here it gives off one or two ciliary twigs, which pass to the posterior part of the globe of the eye, penetrate in an oblique direction the sclerotic coat, and running between it and the choroid membrane, gain the ciliary circle, through which it is difficult to trace them. From this circle they soon emerge, and anastomosing with other ciliary nerves given off by the lenticular ganglion, disappear by subdividing in and upon the iris.

The nasal nerve still pursuing its oblique direction passes beneath the superior-oblique muscle, and sending off its sub-trochlear branch, escapes into the nasal fossæ by the anterior and internal orbitar foramen.

The sub-trochlear branch runs forward along the upper edge of the adductor muscle, as far as the cartilaginous pulley already mentioned. It gives off a filament to the mucous sheath of the tendon of the superior-oblique muscle, and another rather considerable branch, which anastomoses by arch with the super-trochlear branch of the frontal nerve, It then terminates by numerous filaments, some of which ascend into the skin of the upper eyelid, and by others, still more numerous, that ramify on the caruncle at the angle of the eye, the conjunctiva, the lachrymal sac, and the skin at the inner side of the root of the nose. These filaments anastomose with branches of the facial and one of the second division of the fifth pair of nerves.

Recurring to that branch from which the nasal nerve has taken its name, we find that it has entered the nasal fossæ by the anterior internal orbitar foramen; here, however, it delays but a short space, for ascending by one of the posterior holes of the cribriform plate of the æthmoid bone, it enters the separation of the layers of the dura mater that lines this plate on its cranial surface, and passing onwards for the space of about two lines between this membrane, it again descends into the nose by one of the anterior and inner of the cribriform foramina. Here it is observed to be in a minute furrow, between the mesial

line of the nasal bone, and the septum of the nose, giving off fibrillæ to the Scheiderian membrane that lines the cartilage and anterior æthmoidal cells. One or two filaments ascend into the frontal sinus to meet and unite with divisions of the frontal nerve. The nasal nerve is at length continued down, along the anterior edge of the cartilaginous septum to the very extremity of the nose, and ultimately separates into twigs distributed to the skin of this part, and to the alæ nasi, where it anastomoses with branches of the second division of the fifth pair of nerves.

Occasionally the nasal nerve has been observed to be twofold throughout its whole course. I have now before me a subject, in which a second æthmoidal branch penetrates by the posterior and internal orbitar foramen, to be expended at once upon the lining membrane of the nasal fossæ; and in which there is also a second trochlear branch, that terminates by joining the super-trochlear nerve, as did its primitive branch. The anastomosis in this case exists, however, only on the left side.

The Lachrymal Nerve.

The last and smallest branch of the ophthalmic division of the fifth pair of nerves is *the lachrymal*, which sometimes comes off separately, though generally from a trunk common to it and to the nasal nerve. It takes an outward course to the orbit, through a distinct fissure in the dura mater two or three lines in extent. In this canal it forms a very

complicated plexus, of a pale red hue, intimately entangled with the fibrous laminæ of the dura mater, and exceedingly difficult to trace without destroying some of its filaments. Nothing in fact can be more close than its adhesion to this membrane, and if once the thread of the nerve be broken, we may look long in vain to discover its passage through this particular part of the cavernous sinus. Although I have never actually observed a branch of the sympathetic system to join it here, yet its plexiform appearance, its softness of texture, and its reddish colour, indicate its connexion with the involuntary class of nerves.

Escaping from this plexus, in a single trunk, it enters the orbit by the sphenoid fissure, between the periosteum and the outer root of the abductor muscle of the eye. Here it divides into two branches; the external, by far the smaller of the two, anastomoses with the superior maxillary branch of the second division of the fifth pair of nerves, and occasionally with the external temporal branch of the same nerve, through the spheno-maxillary fissure.

The larger portion, in fact the continuation of the lachrymal nerve, passes forwards to the lachrymal gland, which it usually enters in two divisions. To this gland and to its several lobules it gives many branches, dividing and subdividing in its interior structure. Some twigs, however, again emerge, of which one, penetrating by a small foramen in the malar bone, gains the cheek, where it anastomoses with the facial nerve. The remaining fibrils are distributed to the muscle and skin of the upper eyelid, as well as to the conjunctiva. Here they anas-

tomose with branches of the frontal nerve of the first division, and even with the infrâ-orbitar of the second division of the fifth pair of nerves.

The lachrymal nerve presides over the secretion of tears, as well as over the sensibility of the parts to which it is distributed. Mr. Swan, in his splendid engravings of the cerebral nerves, represents this nerve as formed by a junction of the fourth and first division of the fifth nerve: and in the descriptive part of the work, describes it immediately following the fourth. Although I have distinctly observed this anastomosis, it is at least difficult to trace any *physiological* association between a muscular nerve, and those presiding over the function of secretion.

The Lenticular Ganglion.

The lenticular ganglion is one of the smallest of the chain of the sympathetic system; and although situated deep within the orbit, it is connected by intermediate filaments with the superior cervical ganglion.

It occupies the posterior part of the orbit, lying close at the inner side of the optic nerve, almost in contact with it, and immediately at the inner side of the posterior attachment of the abductor muscle, in the angle formed by the entrance of the third and nasal nerves.

In figure it approaches to square; in colour it is of a palish yellow. At its posterior angles it sends off two branches of communication; one, and the larger, runs backwards into the cavernous sinus to unite

with the nasal branch of the ophthalmic division of the fifth pair of nerves. Then separating from the nasal nerve, and ramifying on the sides of the internal carotid artery, and within the bony canal that contains this blood vessel, it unites with other sympathetic nerves communicating directly with the superior cervical ganglion. The other posterior branch unites with that filament of the common oculo-motor nerve, which supplies the inferior oblique muscle of the eye-ball, and is probably the source of the involuntary description of power of this muscle.

From the anterior angles of the lenticular ganglion two bundles of fibres are sent off, known under the name *of ciliary nerves:* these are divided into superior and inferior. The superior and smaller set, containing commonly about six filaments, and passing above the level of the optic nerve, diverge towards the posterior part of the globe of the eye; the innermost fibres anastomosing, by subdivisions, with the ciliary threads furnished by the nasal nerve: they also unite in like manner with the inferior fasciculi. These latter nerves consist of about ten or twelve twigs, and pursue a like course with the former set, with this difference, however, that their direction is beneath instead of above the optic nerve. In this part of their course all the ciliary nerves are tortuous, anastomose frequently with each other, are accompanied by several small arteries of the same name, and embedded in soft and semifluid fat. Having arrived at the posterior part of the eye, the ciliary nerves begin to enter the sclerotic coat, at the distance of about one-third of an inch from the

point where the optic nerve penetrates, and in a circular direction round this nerve.

In perforating the sclerotic coat, the ciliary nerves proceed obliquely forwards, enclosed for a short tract, not exceeding a line and a half in extent, in a kind of small canal, before reaching the interior of the sclerotic; which when accomplished, as is conjectured without supplying to it any branch or filament, they are found, in a flat and ribbon-like form, lying upon the choroid membrane, and connected to it by means of loose cellular tissue. From this point, where their number usually amounts to about sixteen, the ciliary nerves proceed without dividing, as far as the ciliary circle, then giving off at each side a branch, they disappear, and for a time at least seem lost in this texture. Shortly, however, they emerge, and may be seen as small white fibrillæ, passing into the substance of the iris as far as to the very circumference of the pupil; certain small twigs also being distributed to the ciliary processes.

In consequence of the difficulty of tracing the minute filaments of these nerves through the ciliary circle, and because of the marked manner in which they emerge from it, some anatomists have been led to consider the cilary circle as a true ganglion, and a genuine link in the chain of the sympathetic system of nerves. If, however, its size be compared with the organ, to the supply of which it appears to be solely destined, such a conclusion seems to be inadmissible, even if its close and intimate connexion with several other tissues that meet at this point,

did not lead to the conviction, that it is merely a cellular band, or point of general connexion amongst them. From the numerous inter-communications of the ciliary nerves with the third and fifth, and occasionally with the sixth nerve, both the voluntary and involuntary muscular actions of the iris, and the sensation of its general texture, are derived.

It is remarked by some anatomists, amongst whom is M. Ribes, that a small filament proceeding from the lenticular ganglion also accompanies the branches of the ophthalmic artery, and even the centralis retinæ, into the interior of the eye; thus bringing the optic nerve itself into direct sympathy with the organic system of nerves.

Lymphatic Absorbent Vessels.

Very little is known with certainty concerning the absorbent vessels of the eye, or of the lymphatic glands of the orbit, although some very successful injections have demonstrated the presence of certain minute ramuli upon the eyelids. These vessels have, hitherto, been traced to the glands lying over and upon the parotid gland, and beneath the level of the lobe of the ear, rather than to the interior of the orbit. In point of fact, there is at present no direct or positive proof of the existence of absorbent vessels in the globe of the eye, or indeed of any other than certain minute granules occasionally observed at the inner side of the lachrymal gland. These bodies, probably nothing more than small detached portions

of this secreting organ, have been considered and designated by certain anatomists, the "glandula lachrymalis minor."

The absence of absolute demonstration, however, does not authorize the conclusion, that no such vessels as lymphatic absorbents exist in the eye, or in the orbit. Every other circumstance, whether physiological or pathological, leads to an opposite inference; and on the whole it is more than probable, that lymphatic vessels do not only exist, but exist in great abundance, although concealed from the eye of the enquirer by their extreme minuteness and transparency.

Sir Everard Home has, indeed, expressed his conviction that a lymphatic absorbent vessel does actually pass through the so called foramen of Soëmmering: but I conceive no such opening exists; and certainly, since the expression of Sir E. Home's opinion, although this subject has excited and obtained much attention, the existence of such a vessel continues still a question, and remains to this hour unconfirmed by the observations of any subsequent enquirers. In addition it may be remarked, that in a physiological point of view, it is hardly probable that that precise spot in the retina, which of all others appears to be possessed of the most exquisite sensibility, should be occupied by a vessel utterly devoid of any similar property.

Secretion, too, and absorption, are constantly occurring in the globe of the eye, and both so nicely balanced in the healthy state of the organ, that a peculiar kind and degree of firmness and resistance

is at once recognized by the finger of the ophthalmic surgeon. If by a wound or puncture of the cornea, the aqueous fluid be discharged, in twelve or fourteen hours it will be reproduced; demonstrating, under certain circumstances, the rapid progress of secretion. Nor is it probable, that the action of absorption is less vigorously performed; because, if in certain morbid states of the organ the balance of these two opposite functions be destroyed, a dropsical condition of the eye ensues, and occasionally an enormous distention of the globe occurs.

In the severer cases of iritis, large effusions of lymph are poured out, either in a tubercular or arborescent form, and deposited upon the surface of the iris: the serous membranes, also, lose their natural and healthy transparency. As soon, however, as the excessive vascular action is arrested by the use of mercury, so soon do these deposits of lymph begin to disappear. In no other organ of the entire system is the "modus operandi" of the remedy so distinctly shewn, or the peculiar functions of the absorbent vessels so easily observed, as through the cornea, or true window of the eye.

In observing the progress of cure in the treatment of iritis, as soon as the mercurial influence is well established in the system, the depositions of lymph may be seen eaten into, as it were, and varying in form from day to day, by the successive abstractions and removal from their surfaces. The tubercles and effusions disappear; the adhesive bands are loosened; the opaque membranes recover their transparency; and the iris regains its original brilliancy

and freedom of action. These phenomena cannot be explained, at least in the present state of science, on any other theory than that of an absorbent function in action in the interior of the eye: and the only reasonable question that can be raised on the subject is, whether this function is lymphatic or venous; in other words, whether the veins do here exert that power, which under peculiar circumstances they unquestionably do in certain other organs; or, whether for this essential purpose there does exist a separate and distinct class of vessels, hitherto undemonstrated by the labours of the anatomist.

If the existence of lymphatic absorbents in the interior of the eyeball be admitted, they must, in like manner, be allowed in the orbit; and as no glands have yet been discovered in this cavity, it is not unlikely that they may be found to communicate, in part, with the superficial absorbents of the face; and that others may pass out of the orbit, by the spheno-maxillary fissure, to reach the deep absorbent glands of the neck.

The Fat and Cellular Tissue of the Orbit.

The fat of the orbit is much more soft and oily than in any other part of the body; it is divided into several small packets, irregularly shaped, and found chiefly at the posterior part of this cavity. The oil, as is the case in adipose membrane generally, is contained in small vesicles, which in the

orbit are rather larger and more pear-shaped than elsewhere. They are but loosely connected with each other, and the several lobules which they contribute to form, move with great ease and freedom among themselves. Thus a soft and highly elastic cushion is produced, on which the globe of the eye is placed, and on which it moves in every direction with but little friction or resistance. More anteriorly, the fat is intermingled with denser cellular bands, which are the sheaths of the blood-vessels and nerves, as they thread the fat of the orbit on their way to the muscles, globe of the eye, and skin of the eyelids. In proportion as the fat diminishes anteriorly, so do we find an increase of cellular membrane, which is concentrated into sheaths, and forms bands of connection between the inner and more external organs.

In tracing the muscles of the eye from their origins up to their insertion in the globe, we find them invested with dense membranous sheaths, much more strongly marked, however, upon their tendinous expansions, and which in fact are here connected with each other to form a cellular investment for the anterior part of the eye, as far as the margin of the cornea, and interposed between the sclerotic and conjunctival membranes. From the cartilaginous pulley of the superior oblique, muscle to the point of insertion of that muscle, we find this dense cellular membrane forming a complete canal, lined at its most anterior part with mucous, or muco-synovial membrane; affording a specimen of a true bursa mucosa. Here we may stop, for an instant, to

admire the beauty of this provision; for when we recollect the sharp angle at which the tendon turns, and the hard substance over which it plays, we are struck at once with the necessity which existed for some means of diminishing friction, and of increasing the facility and the rapidity of the motion peculiar to the eye: in no way could this have been more perfectly accomplished than by the intervention of a bursa, as occurs in various other parts of the body, where tendons play over hard or bony prominences.

The sheath which invests this tendon, and those that are found on the inferior oblique, and the ocular aspect of the straight muscles, coalesce into one membrane, and form a cellular capsule loosely adherent to the sclerotic coat as far back as the entry of the optic nerve. Some mention was made of this investment at page 166; and it will be easily recognized by those who are in the habit of dissecting the human eye for preservation in spirits of wine, since without a removal of this capsule, the preparation always exhibits a ragged and unneat appearance.

The use of this cellular capsule is to diminish the friction of the muscles playing over the globe of the eye, and to facilitate the motion of the organ, in a manner somewhat similar to the action of the inter-articular cartilages of certain joints.

SECTION IV.

The Defenses of the Eye.

The tutamina oculi, or defenses of the eye, properly so called, comprehend the bony orbit, the eyebrows and the eyelids with their muscles, the eyelashes with their glands, and a delicate cellular and strong fibrous tissue, and the lachrymal apparatus.

The mechanism of this latter structure, although partly contained within the orbit, and partly external to this cavity, as being destined to the secretion and absorption, or carrying off the tears, seems to require a separate and distinct consideration; but, because that its principal office is to guard and protect the eye from the injurious consequences of the various irritating causes to which the eye is from its position necessarily exposed, anatomists have generally classed it among the defenses of the eyeball.

The orbit has already been described as a kind of bony case, or socket, having a pyramidal form, and enclosing and protecting behind and on either side, the globe of the eye with its various muscles, nerves, and blood-vessels; yet, however, it was necessarily left open in front, in order to secure an ample field of vision, and that the eye might be rotated with the

greatest freedom in any direction, towards the various external objects by which we are surrounded. This aperture exists then in form, position, and extent, the most favourable to secure the perfect performance of this important function; but, as an inevitable consequence, exposure to external annoyances and liability to injury are incomparably greater in front than either laterally or behind, hence the necessity of some apparatus or contrivance, at once sufficiently mobile and sensitive, to protect in the most perfect manner possible the anterior part of the organ of vision from the noxious influence of external agents. This result is accomplished by the beautiful provision of the eyelids, a sort of muscular curtain, endowed with a sensibility alive to the lowest degree of irritation, and closing with the quickness of almost light itself, by a process of contraction denominated nictitation, to prevent the intrusion of any foreign body, and to protect the cornea from all causes calculated to impair its polish, or lessen its transparency. On the perfect co-operation of all the textures, and on the exact performance of all the functions of the eyelids, depends not only the beautiful expression of the eye, but also the perfection of vision. In conclusion, as disease, in various forms and degrees, so frequently commits its ravages on this somewhat complicated mechanism, the investigation of its minuter organization, and the actual working of its various component parts, becomes at once a highly interesting and useful duty.

The Eyebrows.

When treating of the frontal bone, we remarked the arched line, that forms the upper boundary of the orbit, extending between the internal and external angular processes. This arch is the most prominent part of the verge of the orbit, and together with the projection of the nasal bones defends the eye, in a certain extent, from the application of the direct violence of large bodies. At about three fourths of an inch from the middle line of the root of the nose, the superciliary ridge is indented by a notch, generally converted into a foramen by a transverse ligament, transmitting the frontal nerve. Somewhat to the inner side of this, is another slightly indented and smooth notch for other branches of the same nerve, as they emerge from the orbit, and creep over the brow to supply the skin and the muscles of the forehead. It is important to bear these points in mind for reasons of practical surgery, as in certain instances the knife may be occasionally required for the division of the frontal branches of the fifth pair of nerves, in cases of severe neuralgic disease.

Above this arch or superciliary ridge, we observe a rough prominence of bone proceeding upwards and outwards from the root of the nose, more or less protuberant in different individuals, according to the greater or less developement of the frontal sinus. Upon this prominence is placed the eyebrow, which as is well known, is only a dense series of short hairs, extending in a slightly arched direction from above the inner angle of the eyelids towards the

temple. The extent and degree of curvature of the eyebrow differs in different persons and sexes. The hairs of which the brow is composed are short, curved, and highly elastic; implanted into the skin obliquely, with their convexities directed forwards, their apices outwards and towards the transverse centre of the brow; so that they form a slightly prominent ridge, which runs through the centre of the line from within to without. The eyebrows occasionally meet in the middle line above the root of the nose, where, however, the hairs are implanted more sparingly than elsewhere; they are always most thick above the superciliary notch, and terminate in a thin series towards the outer angle of the frontal bone, in what is called the tail of the eyebrow ("cauda supercilii"). The fulness of the brow is increased by a small quantity of fat and muscle beneath. Its motions are two-fold: it is raised by the occipito-frontalis, and depressed by the corrugator supercilii muscles.

The Occipito-Frontalis Muscle.

This muscle arises by tendinous and fleshy fibres from the posterior part of the temporal and occipital bones, at the upper of those transverse lines marked upon the latter bone. From this point are formed two fleshy bellies, distinguished from each other by a fine cellular mesial line, and which soon give place to a broad tendinous aponeurosis, that covers the parietal bones, and part of the temporal fascia at each side. Arriving at, or just passing the upper

and posterior border of the frontal bone, the tendon gives place to two new fleshy planes descending towards, and somewhat contracting in breadth as they approach the eyebrows. At the central line the muscle sends off two fleshy slips, which passing down on each side of the root of the nose, meet the ascending origins of the levator labii superioris alæque nasi muscles. The greater part of the occipito-frontalis muscle is inserted into the skin and cellular membrane of the eyebrows, covering the corrugator supercilii, and covered in turn by the upper portion of the orbicularis palpebrarum muscle. At the outer angles it gradually loses itself, by inserting its disgregated fibres into the external part or tail of the brow, and outer portion of the orbicularis muscle, with which it is closely interwoven. Its anterior fibres are intimately adherent to the skin of the forehead, and traversed by many twigs of the frontal and superciliary nerves. Its source of muscular power is derived, in the fore part from branches of the facial nerve, and behind from the occipital nerve. In its action, it not only throws the skin of the forehead into folds, but raises and expands the brow, and slightly opens the outer angle of the eyelids. Its action is best exemplified when *staring* attentively upwards in a moderate light.

The Corrugator Supercilii.

This muscle arises by tendinous and fleshy fibres from the nasal process of the frontal bone, shortly

above the internal angular process, and increasing in breadth and thickness, is placed over the prominence which marks the situation of the frontal sinus; it terminates by a still broader, but very thin fleshy expansion, which is lost in the skin of the outer part of the eyebrows, intermixing with the anterior portion of the occipito-frontalis and orbicularis palpebrarum muscles. The shape of this muscle is somewhat crescentic, its convexity being turned obliquely upwards and inwards. Its action is to depress the eyebrow, and with its fellow of the opposite side to draw them closer together, shading the eye from excessive light. So far as the eyebrows are concerned, it is an antagonist muscle to the occipito-frontalis; and when called into strong action, produces that sombre expression of deep thought and majesty, so remarkable in some of the antique statues of Jupiter Olympus: it also expresses the more energetic passions of anger or hate; this action is termed *frowning*.

The eyebrows are raised and depressed by the two muscles just described, but the orbicularis palpebrarum, when strongly contracted, also acts somewhat upon them; but as this muscle more properly belongs to the eyelids, its origin and insertion will be given hereafter.

The uses of the eyebrows are to defend the eye from various inconveniences, as for instance,—to shade the eye in too vivid a light, to prevent the perspiration from flowing down from the forehead to the fissure of the lids; also to express various passions and emotions of the mind; and lastly, to give

beauty and expression of character to the physiognomy.

The eyebrows are thicker, and more bushy in the male; more delicate, and finely pencilled in the female.

The Eyelids.

The eyelids, or moveable cuticular curtains suspended before the eye, are composed of skin, cartilage, ligament, muscle, mucous membrane, glands, hairs, and peculiar cellular tissues. Simple as they may appear, if viewed externally and without reference to their physiological arrangement, still there is no little complexity in their minute organization; and upon the nice adaptation and close correspondence of each lid with the other, and both with the eyeball, depends not only the perfection of vision, but also the actual safety of the organ.

The lids are two in number, distinguished into upper and lower, and divided by a transverse fissure, which has improperly been called the equator of the eye, since it will be found that this division is much below the transverse centre of the eye: were this not the case, considering how limited are the motions of the lower lid, the eye, or rather the cornea would be only half uncovered in what is called opening the eye. Nor is it altogether correct to say, that the fissure of the eyelids is mathematiclly transverse, since the external angle of the eye is slightly lower than the inner, giving a degree of obliquity to this line, more or less strongly marked in different

individuals. The reverse, however, is the case in the Chinese, where the peculiar expression of the eyes, to a considerable extent, depends on the greater depression of the internal angle of the palpebral fissure. The upper eyelid is much more moveable than the lower, and has a muscle, the levator palpebræ superioris, specially destined to its use; its name implies its action. On the contrary, the closure of the lids is effected by a muscle common to both, known by the name of orbicularis palpebrarum. The eyelids upwards are continuous with the skin of the brows and forehead, downwards with the cheek: they are bounded internally by the nose, and externally by the temple. The orbitar ridge and the eyebrow, is a sufficient indication above of the separation of the skin of the lids from the integument of the forehead; while from the inner angle of the eye a furrow, more or less strongly marked, passing in a curvilinear direction downwards and outwards, and terminating towards the temple, isolates, as it were, the peculiar cellular tissue of the eyelids from that which covers the face generally. This line or *palpebral furrow* it is essential to mark, as in operations for the removal of tumours from this situation, it points out the direction of the necessary incisions. When the eye is closed, the lids present a convex surface anteriorily, corresponding to the shape of the globe, and divided unequally by the transverse line garnished with rows of hairs.

The skin composing the exterior of this apparatus is very thin and delicate, allowing the veins in their serpentine course to shine through, as is so

beautifully described by Shakspeare, when speaking of the sleeping Imogen—

> "The flame o' the taper
> Bows towards her, and would underpeep her lids,
> To see the enclosed lights, now canopied
> Under these windows: White and azure, laced
> With blue of heaven's own tinct."
>
> *Cymbeline.*

The cellular tissue beneath is very lax, and devoid of fat, since, as is obvious were adipose tissue to enter into the composition of the eyelids, its developement in obesity would greatly impede the functions of the organ. What this effect would be, under such circumstances, is exemplified in the occasional disease called œdema, where the eye is sometimes wholly closed by the serous infiltration of the lax cellular tissue. In the healthy state, the cells of this membrane are moistened by a thin and limpid serosity.

The fissure of the lids is rendered firm and even, and constantly preserves its relation to the surface of the globe, by the insertion of two small fibro-cartilaginous bodies at the free edges of the lids. These free edges are named the tarsi of the lids, hence the term *tarsal cartilages* applied to these bodies. They are crescentic in form, the cord of the arc being placed at the edges of the lids. They are also curved in their transverse direction, with their concavities facing towards, and corresponding to, the anterior surface of the globe of the eye. They are of a yellowish colour, highly elastic, and partake in their

organization of the properties of the ligamenta subflava. Their ocular aspect is lined with mucous membrane, and anteriorly they are covered by the fibres of the orbicularis palpebrarum muscle, and by the skin of the eyelids. Their free edges give support to the line of the palpebral fissure, and are anteriorly bounded by the row of eyelashes, posteriorly by the openings of the Meibomian glands. They form the point also where the external skin comes in contact with, or is resolved into, mucous membrane. The upper tarsal cartilage is more than double the size of the lower.

From the circumference of the bony orbit, almost close up to the convex edges of the tarsal cartilages, a strong ligamentous fascia may be observed, interposed between the skin and muscles and the mucous surfaces of the lids. This has been called the *ligamentum latum palpebrarum*, not that it has any strict claim to be considered as a proper ligament, but rather as a fascia giving firmness and support, and connecting and binding together their various tissues. It is said to arise from the periosteum of the orbit, which arriving at the circumference, splits into two laminæ; one of which passing over the forehead above becomes pericranium, and below upon the cheek periosteum of the face; while the other layer converges towards the palpebral fissure, is covered anteriorly by the orbicularis palpebrarum muscle, and is lost by a few scattered fibres at the convexities of the tarsal cartilages.

Through this fascia penetrate the nerves and vessels of the orbit to reach the forehead, and to form

their anastomoses at each angle of the eye. It is chiefly by the intercrossing of the fibres of this aponeurosis at the outer angle of the lids, that the upper and lower fibro-cartilages are connected with each other; a boundary being thus placed to the palpebral fissure at this point, which is called the *outer and lesser canthus* or *angle* of the eye.

The *inner canthus* is the point where the tarsal cartilages are again brought into relation with each other, through the intervention of a true ligament, which here firmly connects them with the bone, and forms the fixed point to which all the motions of the orbicularis muscle more or less concur. This band of union is a narrow ligamentous slip, which is fixed firmly to the point of junction between the internal angular process of the frontal bone with the nasal or ascending process of the superior maxillary bone. From this point it passes horizontally outwards in front of the lachrymal sac, and splits into two thin slips, which are attached to the inner edges of each tarsal cartilage: to this ligament are also fixed the inner fibres of the orbicularis palpebrarum muscle. A little external to the insertions of the ligamentous slips, and at the extreme margins of the eyelids, are seen two small foramina, one above and one below; these are the puncta lachrymalia, more particularly to be described hereafter.

The opposing edges of the tarsi are thicker than in any other direction, and present a flat surface to each other when the lids meet. Some authors, however, assert, that the tarsal edges are cut obliquely at the expense of the posterior border; so that,

when they are closed over the front of the eye, a small triangular canal is formed between them and the globe, which facilitates the passage of the tears from the upper and outer extremity of the eye, towards the inner canthus or lacus lachrymarum.

Between the skin and the edge of these fibro-cartilages, are implanted double or triple rows of hairs, well known by the name of *eyelashes*. These hairs are highly elastic, longer and more numerous in the upper than in the lower lids; fine and scarce at the inner angle of the eye, they become more densely arranged, and firmly set about the centre of the palpebral fissure, and decrease again in length and frequency towards the outer canthus. In the upper lid they are curved, with their convexities looking downwards, their points upwards and forwards; the reverse is the case in the lower lid: so that when the palpebræ are closed, the lashes intermingle and intersect each other at their extreme convexities, which thereby forms a sort of mesh-work that intercepts flying particles of dust, and other light substances, whose contact with the eye or sensible mucous surface of the lids would cause great uneasiness and inconvenience. That this evil does follow the absence of the eyelashes, is well exemplified by the irritability of the eye and dimness of vision, so constantly attendant upon the disease called Lippitudo. The lashes are covered by an oily fluid, which is secreted by numerous cuticular follicles, placed along the external margins of the lids: this secretion tends to keep the hairs separate from each other, and prevents the agglutination

that would otherwise take place from the drying of the lachrymal fluid, mixed as it is with the Meibomean secretion. This, in fact, often takes place, and produces not only an unsightly appearance, but also some optical inconveniences in cases of chronic ophthalmia, where the general secretions of the lids are vitiated and thickened. The length of the eyelashes, and the tone of their colour, greatly regulate the beauty of the countenance, as has been sung by many poets, past and present.

Along the margins of the lids situated internally with reference to the eyelashes, or more correctly speaking, between the extreme posterior edges of the tarsi and the conjunctiva, or mucous membrane that lines the lids, may be seen a regular row of minute apertures. These are the orifices of the glands, called, after their discoverer, the *glands of Meibomeus*. Between thirty-five and forty are found in the upper, and about twenty-five or thirty in the lower lid. The Meibomean glands consist of several compound follicles, placed perpendicularly with reference to the lids, or transversely to the length of the fibro-cartilages; they are lodged in minute furrows, formed in the posterior surface of the tarsi, and covered by the conjunctival membrane. Viewed from behind they appear like a number of small granules, disposed in a somewhat serpentine order of lines from above downwards in the upper lid, and contrarywise in the inferior: they terminate by an open mouth in the margin of the tarsi. Each granule is a sebaceous follicle, communicating with a duct forming the line surrounded with these little bodies,

and discharging the collected secretion of each series of them upon the palpebral fissure. The rows of glands are more numerous and longer about the centre of the tarsal cartilages, becoming disgregated and irregular as they approach either canthus. The secreted fluid is in its nature albuminous and miscible with the tears ; but after death it becomes inspissated and opaque, and may be squeezed through the orifices of the ducts in a vermicular shape, displaying in a most distinct manner the arrangement of these openings. Hence it appears, that each of these parallel collections of Meibomean glands is a compound follicle, into whose central duct each simple gland secretes its fluid, which is finally poured out upon the inner edges of the tarsi, and by mixing with the tears diminishes the friction of the lids in their movements upon the cornea and anterior surface of the sclerotic coat.

The Caruncle.

This small body has been called somewhat improperly, the *lachrymal caruncle,* whereas it is only a small collection of mucous glands situated in the greater angle of the eye, immediately behind the internal junction of the fissure of the lids. The mucous membrane, or conjuctiva, which is here very loosely reflected over it, is pierced by a few small apertures, which are the mouths of the excretory ducts of these glands. Each duct is garnished with a minute hair planted close to its orifice.

The Muscles of the Eyelids.

The motions of the eyelids are performed by two muscles, one common to both, and one proper to the upper lid. The former is named the orbicularis palpebrarum, the latter levator palpebræ superioris.

The orbicularis palpebrarum as its name implies, is common to both eyelids. In form it is a flat and oval muscle, at its innermost point corresponding to the greater angle of the eye, which being also its fixed point is assumed as its origin, for the purposes of more perspicuous description. The orbicularis palpebrarum, then, arises from the internal orbitar angle of the frontal bone, and from the nasal process of the superior maxillary bone: it arises also from the superior and anterior edge of the lachrymal fossa, and from the tarsal ligament therein implanted. Its fibres proceed in a semicircular direction, above and below the margin of the orbit; outwardly it passes towards the external angle of the eye, where its fibres closely interlace, and become intimately mingled with the skin. The plane of this muscle lies immediately beneath the integuments of the eyelids, and it is inserted into the skin covering the point of union between the external angle of the frontal bone and the malar bone: also into the skin of the eyelids generally, and into the tarsal cartilages in particular, covering them anteriorly, even so far as to the palpebral fissure, by which the horizontal diameter of this muscle is cleft. The fibres of the orbicularis at the circumference are circular, of a full red colour,

and much thicker than elsewhere, while those more in the centre are paler, thinner, and less curved. This muscle is situated on the frontal bone, covering the whole superciliary ridge, the external and internal angular processes, the orbitar ridge of the malar bone, and the nasal process of the superior maxillary bone. Its upper fibres are intermixed with those of the occipito-frontalis; below it covers one of the zygomatici muscles as well as one of the origins of the levator labii superioris alæque nasi; its inner fibres interlace with the long head of the last named muscle, with the nasal fibres of the occipito-frontalis, and with the corrugator supercilii muscles. The few pale and horizontal fibres which immediately cover the tarsal cartilages and which are continued to the edge of the palpebral fissure itself, have received the name of "*musculus ciliaris.*" The facial nerve supplies the orbicularis with muscular power; its sensibility is derived from the first and second divisions of the fifth nerve. Its use is to cover and close the eye, and should be classed according to Albinus "in sphincterum numero." Its action is called nictitation or winking. By compressing the lachrymal gland it produces a free flowing of the tears, diffusing them over the surface of the globe of the eye and inner part of the eyelids, conducting them in a direction from without, inwards. Sir Charles Bell has observed, that in closing the lids, the upper one descends perpendicularly, while the lower one performs a sort of traversing movement, which he compares to the direction of a shuttle through the threads of a loom. The tonic power of the orbicularis muscle,

by its pressure on the globe of the eye, restrains the actions of the levator palpebræ superioris, and of the oblique muscles, from protruding it too far beyond the plane of the orbit. That this is the effect of the tonic contraction of this muscle, is demonstrated by what is presented in those cases, where the seventh or facial nerve, on one side only, has been palsied or divided: the eye of the disordered or wounded side is seen to be thrust forwards, as if deep-seated pressure was made behind the eyeball; the eyelids also hanging loose and flaccid, give a vacant or inanimate expression to that side of the face. The orbicularis palpebrarum contracts with a force altogether spasmodic, whenever any irritating or foreign particle falls upon either the globe of the eye or inner surface of the eyelids, and by sudden and involuntary closure of the lids guards this sensible organ from the intrusion of such bodies. Its strength may be estimated by endeavouring to unclose the lids in a child suffering from that intolerance of light so constantly accompanying strumous ophthalmia. Lastly, it antagonizes the levator palpebræ superioris.

The levator palpebræ superioris arises immediately above the optic foramen, and at the earlier part of its course it is slightly adherent to the levator oculi muscle. It is a long ribbon-shaped muscle, passing towards the anterior part of the orbit, immediately below the roof of this cavity, and throughout the greater part of its course in contact with the levator oculi muscle. It rises slightly, moderately increasing in breadth while it looses in thickness, until reaching the anterior half of the globe of the eye it

descends, expanding in a radiating direction as it approaches the upper eyelid. Here it becomes very thin, and is inserted, in front of the eye, into the superior circumference of the tarsal cartilage of the upper eyelid. At this point it is placed behind the fibrous fascia of the lids, above, and in front of the conjunctiva. It is placed near the outer side of, and above, the adductor muscle, and has between it and the roof of the orbit, in its anterior half, the trunks of the frontal and superciliary nerves. Its nerve of muscular action is given off by the third or common oculo-motor nerve.

Its action is to raise the upper lid, to uncover the globe of the eye by drawing the tarsal cartilage beneath the margin of the orbit, and at the same time it slightly protrudes the globe. In this last action it indirectly depresses the lower eyelid, inasmuch as the protrusion of the globe causes the lower lid to slide off its anterior convexity, and thus opens the eye to a greater extent, as in the act of staring.

The Conjunctiva.

A membrane which invests the anterior portion of the globe of the eye, was adverted to, but not described, at page 23; this also covers the posterior or ocular surfaces of the eyelids, belonging to the class of mucous tissues, and by reason of its serving as the connecting medium between the eye and eyelids, and thus producing a continuity of surface, it has obtained from anatomists the appropriate name of

conjunctiva. With a view of facilitating description, more especially in pathological cases, it has also been subdivided into two portions, *ocular* and *palpebral.*

When mucous membranes open upon the external surface of the body, there is a certain definite point at which the skin ceases to exist; or rather, perhaps, where its conversion into mucous membrane begins. Thus at the place where the Meibomean glands open upon the edges of the eyelids, the common integument loses its original character, and is converted into conjunctiva; an effect which takes place throughout the whole extent of the palpebral fissure. If the conjunctival membrane be now traced from the marginal edges of the tarsi, it will be found closely adherent to the posterior surfaces of these fibro-cartilaginous bodies, and covering the vertical ranges of the Meibomean glands. Leaving the arched circumference of the tarsi, it is attached, though very loosely, to the fibrous fascia of the eyelids; and through the intervention of a fine and loose cellular tissue the palpebral conjunctiva terminates in a large and scarcely adherent circular fold. From this point onwards the membrane, now called the ocular conjunctiva, is reflected upon the anterior third part of the sclerotic coat, to which it is closely attached: here, also, it is very thin and transparent, and covers the expanded tendons of the straight muscles, allowing them to shine through, and giving the brilliant lustre to that part of the organ, which in popular language is called the "white of the eye." At the immediate circumference of the cornea, the con-

junctiva adheres still more firmly than elsewhere: ultimately it passes over the surface of the cornea, covering that part throughout its whole extent. The exquisite tenuity and transparency, together with the intimate union of the conjunctiva with the anterior lamina of the cornea, have rendered strict anatomical demonstration a matter of so much difficulty, that many authors have doubted, and some have not hesitated to deny altogether, its existence at this position.

The palpebral conjunctiva near to the inner angle of the eye, and on the extreme verge of the tarsal margins, meets the two little eminences perforated by the puncta lachrymalia. The conjunctiva enters these openings, and after lining, as we shall hereafter see, the lachrymal passages, finally enters the nose, and becomes continuous with the mucous membrane of the nasal cavities. Still more internally the conjunctiva lines the inner canthus and lacus lachrymarum; passing over the collection of small glands denominated the caruncle, it enters the ducts of these minute bodies, and is perforated by their almost microscopic hairs. Posterior to the caruncle, and a little external to it, we again see the conjunctiva under the name of "*membrana semilunaris.*" This little fold is placed vertically between the two eyelids, at their inner angle; it has its concavity directed outwards, and is of a more florid hue, and possesses a much higher degree of vascularity than at any other part of its course. This membrana semilunaris has been supposed to be the rudiment of the membrana nictitans, or the third eyelid of the

lower animals: its principal use appears to be to give increased facility to the movements of the globe outwards, from the looseness of its connections between the eyelids and eyeball. For the same purpose, at the point where the conjunctiva is reflected generally upon the globe, the loose and deep circular fold occurs, and of which the semilunar membrane may be said to be only the inner and completing portion.

At the outer side of the eye and above the globe, where the conjunctiva is reflected from the external angle of the superior tarsal cartilage, we observe a small crescentic line, perforated with six or seven minute apertures: these are the openings of the lachrymal ducts, hereafter to be described.

The palpebral conjunctiva is highly vascular, and is supplied principally by the palpebral arteries of the ophthalmic, and the angular nasal of the facial trunk: externally, also, by ramuli from the lachrymal and temporal arteries. It is endowed with an exquisite degree of sensibility, as the accidental admission of the minutest foreign body indisputably proves. This nervous sensibility is supplied by various twigs of the ophthalmic division in the upper lid, and in the lower by certain branches of the second division of the fifth nerve.

That portion of the ocular conjunctiva that covers the sclerotic coat of the eye, has sometimes been called the "*tunica adnata*." In a state of health, it appears to be little vascular; its vessels are, however, very numerous, and in states of high inflammatory action, red blood is admitted into them so freely,

that the whole membrane becomes distended with blood, and assumes the appearance of a piece of scarlet velvet. Its vessels are principally derived from the muscular and anterior ciliary arteries, whose general direction is from the circumference towards the centre. Its nervous sensibility is wholly supplied by the ophthalmic division of the fifth nerve.

It has been observed, that it is a work of much difficulty to exhibit the conjunctiva upon the surface of the cornea, because that the closeness and intimacy of its connections with this tissue, together with the extreme delicacy of its texture, withdraw it at once from the eye and knife of the anatomist. Bichat, however, asserts that it may be separated and shewn by maceration. In this instance, again, we shall find that pathological observations are of the very first importance in enabling us to solve a question of mere structure. In the disease called pustular ophthalmia, an incipient vesicle is often raised upon the surface of the cornea, and sometimes so near to its very circumference as to be partly upon it and the sclerotic portion of the eyeball. Now as it is certain that the vesicle in question is wholly formed in the conjunctiva, we are enabled to trace with great ease and certainty the continuity of the surfaces. The conjunctival vessels that pass from either angle of the eye, frequently proceed directly to the pustule placed on the cornea. Again, in a particular case, in which there were two or three small fleshy tumours situated upon the tunica adnata, or the sclerotic portion of the conjunctiva, one was placed immediately upon the circumference

of the cornea. They were moveable, and belonged wholly to the conjunctiva, having no attachment to any other tissue. In another case, after severe inflammation, the cuticle itself was observed to have crept from the cheek over the edges of the eyelids, upon the palpebral conjunctiva, the sclerotic, and even upon the cornea itself, which was nearly half covered with true cuticle.

The surface of the conjunctiva can scarcely be said to be villous in the healthy condition of the eye, but the evidence of its mucous nature is so positive and direct, that it hardly needs to be further insisted on.

Lachrymal Apparatus.

In order to protect from external and noxious causes the transparent and brilliant surface of the eyeball, as well as to facilitate its various motions, and those of the eyelids, a peculiar secretory apparatus has been superadded to the organ of sight.

It has been already observed, that the conjunctival membrane furnishes a mucous fluid from its general surface, and that the glands of Meibomeus, ranged along the ciliary margins, cooperate in the performance of this important function. The structure and arrangement of these parts having been described, it only remains for us to investigate the somewhat intricate mechanism of the lachrymal gland and its excretory tubes, with certain small mucous cryptæ found in connection with them.

The secretion of the tears must of necessity, and

at a very remote period, have attracted the attention of anatomists; yet it is certain that their real source eluded the researches of the earlier observers and authors. In the first instance, the little caruncle, situated at the inner angle of the eye, was supposed to be the fountain; and even after the actual discovery of the lachrymal gland, the minute body above mentioned was continued in its office under the denomination of "glandula lachrymalis inferior." From the habitual employment of brute animals, as subjects for dissection, the function or office of secreting the tears was assigned to an organ ("glandula Harderi"), absolutely non-existent in man.

The lachrymal apparatus may be divided into two distinct portions: one secreting; the other distributing and conveying away the fluid furnished. The former of these, consisting of the gland and its ducts, is situated at the upper and outer part of the orbit. It is wholly distinct from, and independent of the latter, which is placed principally at the inner angle of the eye. The tears must, therefore, pass from without inwards, over the anterior surface of the sclerotic and corneal membranes; or more strictly speaking, over the conjunctival coverings of these membranes, before they are finally conveyed through the lachrymal puncta and canals into the nasal cavities.

The Lachrymal Gland.

The lachrymal gland is a compound structure, having an irregularly oval shape, about the size of a

bitter almond, but somewhat broader, and consisting of an assemblage of small granular bodies, collected into lobules, and again into one entire mass by interstitial cellular and fibrous tissue. It is situated a little above and behind the internal angular process of the frontal bone, *within* the orbit, in that depression or hollow noticed and included in the general description given of the several bones of which the orbit is composed. Beneath and to the inner side it has the anterior extremity of the abductor oculi muscle, and it lies upon some of the outermost expanded fibres of the levator palpebræ superioris muscle, separated, however, from it by the interposition of a layer of soft fatty matter. In front it is protected by the broad fascia of the upper eyelid, and by the orbicularis muscle. It is retained within the orbit solely by the fascia, which may be considered as its proper limit anteriorly; upwards and to the outer side it is protected by the roof and outer wall of the orbit. It is concave on its ocular aspect; convex where it corresponds to the roof of the orbit; its thin edge and long axis are placed anteriorly and obliquely across the line of the orbit.

The ultimate divisions of the lachrymal artery ramify through the little glandular grains, and terminate in their respective veins and excretory ducts: the latter, inosculating amongst themselves, finally produce six or seven minute tubes, that conduct the tears to the conjunctival surface of the upper eyelid. These tubes in the human eye are so minute, that it is found to be exceedingly difficult to trace them

without some artificial preparation. To this end, the eyeball and the eyelids, with the lachrymal gland attached, should be carefully removed from their position within the orbit. After due immersion in water, colored with indigo, ink, or blood, the orifices of the ducts in question may be seen on the palpebral conjunctiva of the upper eyelid; prosecuting the observation by injecting them with mercury, the ducts may be traced even into the very gland itself.

The tubes are from three to four lines in length, exceeding minute and transparent, terminating in the conjunctival membrane, where it begins to be reflected from the surface of the upper lid, and arranged in a curved line, above, and to the outer side of, the globe of the eye.

The lachrymal gland is supplied with nervous power, through the medium of the lachrymal branch of the ophthalmic division of the fifth nerve.

The secretion of the tears goes on without intermission, even, as is inferred, during sleep. This fluid has the property of dissolving and holding in solution, as well the mucous secreted by the conjunctiva, as the sebaceous matter of the glands of Meibomeus. Its chemical analysis, as given by Dr. Henry, furnishes water, an animal fluid resembling albumen, another fluid probably mucous, and various neutral salts; to which may be added uncombined alkali (probably soda), because of the known fact, that the tears do change the blue colour of syrup of violet to green.

The functions of the lachrymal gland, within certain limits, are involuntary; but there is scarcely an organ in the animal body more powerfully acted

upon by mental sympathies; and under particular excitement of a moral nature, the secretion is poured forth in such abundance, and with such celerity, that its natural channels are utterly unequal to its timely removal. Instead, therefore, of descending into, and disappearing by, the nostrils, it flows over the cheeks in drops, known by the name of "*Tears.*"

Lacus Lachrymalis.

The lacus lachrymalis is a small space situated at the inner angle of the eye; bounded posteriorly by the caruncle; at the inner side by the junction of the upper and lower lids at their angle; and outwardly by the crescentic fold of the conjunctiva and the puncta lachrymalia. This little hollow may be considered as an arbitrary division of the conjunctival surface for the purpose of facilitating physiological description, rather than as a distinct and separate anatomical structure. It is the point where the tears ultimately collect, after having swept the surface of the globe of the eye, and before they are absorbed by the puncta.

Lachrymal Points and Canals.

The puncta lachrymalia, or, openings of the lachrymal canals, are two in number, one in the upper, and one in the lower eyelid. They are placed opposite to each other, about one line in front and to the outer

side of the caruncle, forming the outer boundary of the lacus lachrymalis. These openings are situated in the centre of small eminences, or papillæ, that incline slightly towards the anterior surface of the eye. They are so minute as to admit with difficulty a small bristle, and are said to be surrounded with muscular fibres in the form of a sphincter, enabling them to contract upon irritation. It is more probable, however, that this apparent contractile power is derived from the swelling of the contiguous and lining membranes, upon the access of mechanical irritation, and is attributable to arterial rather than to muscular action.

Tracing *the lachrymal canals* from the puncta lachrymalia, it is at once perceived that they do not proceed directly downwards to the lachrymal sac, but, that in the instance of the upper lid they ascend, and descend in the lower lid, in a perpendicular direction to the extent of about a line and a half, when they bend at a right angle upon themselves and pursue a horizontal, or at least but a very slightly inclined, course towards the lachrymal sac and duct. Before they reach this point they usually unite and form one single canal; in some instances, however, they enter separately; whilst in other examples when viewed externally there appears to be only one canal, a more careful examination shows that the apparently single tube is divided by an inner septum of fine cellular membrane into two separate ducts. In the perpendicular portion of the canals their diameter, or calibre, scarcely exceeds that of a capillary tube, but at the angle, which they form upon

themselves, a very sensible dilatation occurs with one or two minute mucous cryptæ, not unlike in general structure the lacunæ of the urethra.

This enlargement of the canals, the sudden turn they make upon themselves from a perpendicular to a horizontal direction, and the looseness of the lining membrane, frequently occasion embarrassment to the surgeon in his endeavour to pass the fine gold probe, adapted for this purpose, into the lachrymal duct; the point of the instrument becoming entangled in the loose folds of the membrane and mucous cryptæ. This difficulty may be overcome by extending the lids outwardly, so as to make the line of the canals as nearly straight as possible, and having introduced the probe to the bottom of the first part of their course, by suddenly elevating the point slightly, and directing it obliquely inwards, it passes readily towards the lachrymal sac.

The exterior covering of the lachrymal canals is formed of fibrous membrane, not, as many have supposed, of *muscular* fibres. They are separated from the conjunctival surface of the lids by fine cellular tissue, corresponding anteriorly to the orbicularis palpebrarum, or rather to that portion of the muscle which has received the distinctive name of ciliaris.

It may be proper to mention in this place, that an American anatomist has described a small muscle, whose origin is given as arising from the perpendicular line which divides the os unguis into two parts, and thence passing round, and to the outer side of the lachrymal sac, to which it adheres, splits into two portions to be inserted into the extreme inner

angles of the tarsal cartilages, close upon the puncta lachrymalia. This muscle, which has received the name of *ungui-palpebralis*, is supposed to act upon the lachrymal points and canals, in order to direct them towards the lacus lacrymalis, and to facilitate the absorption of the tears.

The lachrymal puncta and canals, however, are retained in their proper relative situations, in reference to the lacus, by the ligament that connects the cartilages to the bone, as well as by the elasticity of the cartilages themselves, a condition of the very first importance to the functions of these minute structures. The slightest deviation from the natural situations of these parts, in certain morbid conditions of the lids, such as ectropion and entropion, frequently gives origin to the affection called epiphora or watery eye. This complaint may indeed arise from an impervious state of the canals, from thickening of the lining membrane, or from a similar condition of the fibrous coat; but it is evident, that if either the puncta lachrymalia be too closely applied against the front of the globe of the eye, as in entropion, or if as in eversion of the eyelids, they be drawn outwards from the lacus larymarum, the tears will not find their way into the canals, the sac and duct; but will on the contrary make their escape over the surface of the cheek, producing the distressing disease above mentioned. It is the very different kind of treatment, which epiphora, arising from its several various causes, requires at the hands of the surgeon, that makes it of the first importance, that the structure and relative anatomy of these tissues should be investiga-

ted with the utmost care, and stated with equal perspicuity and truth.

Lacrhymal Sac and Duct.

The lachrymal sac is of an ovoid form; upwards it is closed, and lodged in the hollow formed by the anterior portion of the os unguis and ascending process of the superior maxillary bone: it terminates inferiorly in the nasal duct. It equals in size a common goose quill, and rises nearly two lines above the ligament connecting the superior and inferior tarsal cartilages. Anteriorly it is covered by skin, by the orbicularis palpebrarum muscle, and by the tarsal ligament, whence so many fibres of the orbicularis arise. At its outer side, it corresponds to the caruncle and to the conjunctiva, where it receives the lachrymal canals, and has according to some anatomists a few of the fibres of the inferior oblique muscle attached to its exterior coat: these fibres may perhaps be identical with the ungui-palpebralis muscle before mentioned. Its posterior boundary is the perpendicular line that divides the os unguis along its centre. The exterior covering of the lachaymal sac is firm and fibrous: but its internal surface is lined with a mucous membrane, continuous at the side of the lachrymal canals with the conjunctiva, and inferiorly with the lining membrane of the nasal cavities. The superior extremity of the sac, where it is rounded and dilated, is closed; inferiorly, having obtained the name of lachrymal and nasal duct, it is continued into the nose. *The nasal duct*,

or inferior half of this tube, is enclosed in a bony canal, taking a course downwards, backwards, and slightly inwards, contracting as it descends, until it terminates in the inferior chamber of the nose, nearly in the centre of the outward wall of this cavity. The proportions here stated are taken of course with reference to the recent subject.

Looking into the cavity of the nose, the termination of the nasal duct is not instantly perceived, for it is concealed, and as it were, roofed over by the inferior turbinated bone, which forms the upper boundary of this chamber of the nose. The mucous lining of the nasal fossæ is raised into a sort of membranous eminence, surrounding the termination of the duct; and when, as in some catarrhal affections, it becomes inflamed, it gives rise to a stillicidium lachrymarum, by obstructing the regular descent and exit of the of the tears.

The lachrymal sac, with the lachrymal canals and puncta, have been compared to a syphon, of which the nasal duct has been supposed to represent the longer leg. By this somewhat forced comparison, certain theorists have endeavoured to account for the descent of the tears into the nose. Other Physiologists have conceived and taught, that the puncta lachrymalia absorb the fluid secretion of the lachrymal gland by the force of capillary attraction; and the minuteness of the puncta do certainly give some coloring to this hypothesis. That there is no direct vital sympathy between the secretion and absorption of the tears, seems clear from several facts, amongst which, that which follows is the most prominent.

Looking to the source whence the lachrymal gland derives its supply of nervous power, together with the plexiform appearance, the soft texture and red hue indicative of a connexion with the ganglionic system, which is presented by the lachrymal nerve in the early part of its course, no surprise needs to be felt, why the secretion of the gland is liable to be suddenly excited, or increased by direct sympathy with the organ it ministers to, or remotely by the influence of the passions, such as grief, or anger, and sometimes even of unexpected joy. Thus, in an example familiar to all, when the smallest foreign body offends the exquisite sensibility of the conjunctiva, the tears are observed to be so suddenly and so copiously poured forth, that the puncta lachrymalia are incapable of absorbing them with proportionable celerity; the fluid is at first accumulated at the inner angle of the eye, overflows the margin of the lower eyelid, coursing down by the side of the nose and over the cheek. Had the absorption in this case, therefore, not been dependent on some mechanical principle or power, it is probable that the collected fluid would have been carried off by a corresponding increase of energy on the part of the excretory apparatus. In ordinary states of the organ, a large proportion of the lachrymal secretion is abstracted by evaporation from the surface of the eye. In conclusion it must certainly be confessed, that a sound explanation of the laws, that govern as well the secretion, as the excretion of the tears, is still a desideratum in the science of Physiology.

PECULIARITIES EXHIBITED BY THE HUMAN EYE, AT DIFFERENT EPOCHS OF LIFE.

The human eye during the period of fœtal existence presents some remarkable peculiarities which it is essential to notice, as dependent not only on the relative proportions of the various component tissues, but on the presence of some, and the absence of others, at the different epochs of embryonic life.

At the end of the first month of utero-gestation, we begin to perceive the eyes in the form of two minute black points, and up to the tenth week they are easily distinguished on account of the absence of the eyelids. About this time, however, the lids begin to make their appearance, and rapidly increase in size, so that at the expiration of the third month the eyes are no longer visible from the development and closure of the lids. The palpebral fissure remains sealed from this moment until the birth of the child, and apparently adheres from the presence of a sebaceous secretion poured out at the tarsal margins.

The most remarkable of the points in which the fœtal eye differs from that of the adult, or even from that of a new born infant, is in the presence of a membrane which closes the pupil, and has thence been denominated "the membrana pupillaris." This

tissue has been observed as early as the third month, and continues a septum between the anterior and posterior chambers of the eye, up to the middle of the eighth or sometimes the beginning of the ninth month of utero-gestation. A more particular description of this membrane will be given separately.

The sclerotic and corneal membranes are proportionally thicker at the earlier periods of fœtal life; and at the term, the cornea is absolutely double the thickness of that membrane at the adult period. This state of the cornea depends chiefly on an infiltration of a serous fluid between its laminæ, which, being of a dull red colour, greatly diminishes its transparency.

The choroid is relatively thicker, though less dense, than at any future period; the black pigment is not altogether so dark at the posterior part, but is more pulpy, and adheres less firmly than in the adult: it may also be detached in larger masses; it does not however transude the external surface of the choroid. The retina, like the other membranes, is thick and soft, the medullary matter bearing a larger proportion to the vascular web, than in the more advanced periods of life. The central fold is always present, and according to Meckel is absolutely larger than in the grown man: its central depression may be observed, but without the least trace of its yellow circumference.

The crystalline lens is greatly more convex in the fœtus, much softer, and of a dull red colour. Its capsule is plentifully supplied with blood-vessels, which are sometimes found injected with the coloring particles of the blood.

The vitreous body is also colored with the same fluid; and at this time it is by no means a matter of difficulty to fill its central artery, and the various branches distributed on the posterior capsule of the lens, with the minuter descriptions of colored injection.

The eye of a new-born child is, compared with the bulk of the body, greatly larger than in the grown man: the cornea is more convex, but now transparent. It may be observed, that infants are always near-sighted, which may account for the little notice they take of any objects, excepting those which are very close to the organ, or of a peculiarly bright and luminous appearance.

After the middle period of life the eye undergoes a series of changes, of which the opaque ring surrounding the cornea is the most obvious. This ring, or "arcus senilis," is a deposition of grey lymph between the laminæ of the cornea, generally about half a line in breadth, but varying according to the age or peculiarity of health of the individual. It is observed at the circumference of the cornea, leaving, however, a more transparent edge at the extreme point where this membrane joins the sclerotic. The cornea also flattens somewhat in advanced age, either by interstitial absorption, or from the diminished secretion of the fluid which distends the anterior chamber. This circumstance explains the improvement in the sight of such as have been previously myopic, or short-sighted; it not being unfrequent to hear of these persons laying aside their spectacles in old age.

The choroid now begins to secrete less and lighter colored pigment. The iris loses somewhat of its brilliancy and vivacity of motion.

The retina is thinner, and at the expense of its medullary portion: the fold gradually becomes flatter, and even almost disappears. The yellow stain is also so pale as to be scarcely distinguishable.

The crystalline lens diminishes in transparency, acquires a pale opaline tint, sometimes even approaching to an amber hue: it is also manifestly harder in texture, and less convex in extreme old age; which latter circumstance may probably be a reason why convex glasses are assumed so generally by old people, where no morbid alteration can be perceived in the organ.

The vitreous body is more fluid and less transparent, in the aged than in the adult.

Owing to the diminished secretion of the pigment, and its lighter color, combined with the opaline tint of the lens, the pupil instead of presenting the intense blackness of the earlier periods of life, is often in age of a greenish hue. This has frequently been confounded with the disease called "glaucoma;" while the thinness and loss of energy in the retina itself aids the deception, by furnishing in the consequent failure of vision, one of the symptoms of that distressing malady.

I am inclined, however, rather to look upon such appearances in very old people, as indicative of a natural change in the organ, than as a true morbid affection, unless accompanied by other and unequivocal symptoms.

Membrana Pupillaris.

No point in anatomy has been more debated than the question of who first observed and described the "*membrana pupillaris.*" Most modern authors ascribe the honor to Wachendorf. It appears that this anatomist published his account of the membrane in 1740, but that he had discovered it two years earlier. Haller is said to have observed the same structure in the same year, but his published description was not given to the world till 1742. Albinus, according to his own description, had observed this delicate structure so early as the year 1731, and had even caused a representation of it to be engraved in 1737, or one year before Wachendorf claims his first discovery. It is probable that all these authors, as well as Dr. W. Hunter, made their observations without previous knowledge of the discovery of each other. To whomsoever we owe the first history of the pupillary membrane, it is nevertheless true that it was left to modern anatomists to explain its real structure, and relative bearings with reference to the important tissues with which it is connected. To Cloquet this merit chiefly belongs, who published a monograph on the subject of the membrana pupillaris, at Paris, in the year 1818. A still more recent treatise by F. G. Henle (Bonn, 1832), although it differs to a certain extent from the memoir of Cloquet, still adds somewhat of valuable information to our previous knowledge of this structure

Passing, therefore, the descriptions of the older anatomists, among whom, however, that of Wrisberg may be selected as one of the best, we shall consider the membrane in question according to the more recent observations of the two authors above mentioned.

If we examine the eye of a fœtus in the beginning of the seventh month of utero-gestation, we shall find the pupil shut up by a fine membranous septum, which divides the anterior from the posterior chamber of the eye. Each cavity is in fact occupied by a small quantity of aqueous fluid, although this fact has been denied by several anatomists of note; some maintaining that the anterior chamber contains no fluid secretion prior to the rupture of the membrana pupillaris. In a note to Majendie's Physiology, we find that such is the opinion of M. Edwards. Cloquet, on the contrary, and Meckel, assert its presence; and the former points out many modes of proving the fact. All these authors, however, agree in the circumstance of the posterior chamber being filled with this secretion. These positions must be borne in mind as having a distinct relation to the nature and function of the membrana pupillæ.

Let us first investigate the opinion of Cloquet, as to the anatomical situation of the membrane. He says that it is formed of *two laminæ*, applied one against the other at the pupillary opening: that the anterior layer proceeds at first from the concave surface of the cornea, which it lines, and to which it firmly adheres; that it is then reflected on to the anterior surface of the iris, even up to the margin

of the pupil at this point it leaves the iris and stretches across the pupil, and closes it at the centre, forming one complete and continuous membrane, a shut and serous sac. Of the posterior lamina he says but little, in fact simply that "le postérieur appartient à la chambre correspondante de l' œil, et nâit du pourtour de la pupille."

Henle however, goes considerably further, and, after attributing the first mention of the discovery to Professor Müller, describes the posterior layer as the "membrana capsulo-pupillaris." "Oritur," says this anatomist, "unâ cum membranâ pupillari ex iridis superficie anteriori, quam tegit ab ortu usque ad marginem pupillarem; hinc, cum partibus adjacentibus nusquam cohærens, retrorsum et ab axi visionis extrorsum inclinata, oculi cameram posteriorem percurret, et ad capsulæ superficiem anteriorem adjungitur, ubi zonulæ Zinnii marginem internum ponere solemus." Thus we have a second closed and probably serous sac, since in the posterior chamber the same aqueous fluid is found as in the anterior.

At the pupil the two layers are adherent to each other, and unless artificially prepared, they are colorless, transparent, and apparently deprived of blood vessels. Minute injections of size, or turpentine colored with carmine, may, however, with a little care be so forced into the arteries of the iris and ciliary processes, that we shall have little difficulty in discovering them distributed in a peculiar order between the two laminæ of the membrana pupillaris. It will be remembered when describing the vessels of the iris at page 65, that the

two long ciliary arteries were said to form, by their anastomoses with each other, the larger vascular circle; and that from its concavity several radiating branches, accompanied by many similar divisions of the anterior ciliary trunks, passed towards the pupil to form the lesser circle, a short distance from its extreme margin. According to Cloquet, this lesser circle does not exist in the fœtus, but that instead of such a disposition the vessels pass beyond the edge of the pupil between the two laminæ of its closing membrane. "Ils s' advancent," says this author, "jusque vers le centre de la pupille, en représentant des anses très flexueuses, de grandeur et de figures variables, dont la concavité repond à la circonfèrence de cette ouverture. Ces anses sont fort nombreuses, elles ne s' anastomosent pas avec celles qui leur sont diamétralement opposées, mais seulement avec celles qui sont sur les côtés; il résulte de cette disposition fort curieuse, qu'il reste entre la convexité de toutes les anses vasculaires, et vers le centre de la pupille, un espace assez irrégulier, dans lequel la membrane est dépourvue de vaisseaux, et beaucoup plus foible par conséquent que partout ailleurs."

The arteries of the posterior lamina Henle derives from the branches of the posterior capsular artery of the centralis retinæ, which arriving at the extreme circumference of the capsule are distributed to the membrane lining the posterior chamber, and anastomose with twigs given off from the arteries which supply the ciliary processes. Dr. William Hunter was also clearly aware of this fact, since he says "the membrana pupillæ receives two different sets

of arteries; one larger, from the iris, and the other much smaller, but very numerous, from the crystalline capsule."

Towards the end of the eighth month, often earlier, and sometimes at a later period, the membrana pupillaris begins to disappear. The absorption or rupture of this tissue generally commences in the centre and the vascular arches gradually contract, till nothing except some minute vascular shreds are seen floating in the fluid of the chambers of the eye. The radiating arteries now withdraw into the edge of the iris, and anastomosing with each other form the lesser vascular circle. After birth they still continue to retire, until in the adult, the lesser vascular circle is found situated entirely on the anterior surface of the iris at some little distance from the edge of the pupil. Shortly before birth the vessels of the capsule of the lens are so far diminished in their calibre, that they no longer carry red blood, and except in very rare instances, our most minute injections fail to display their existence on the anterior capsule.

The central portion of the membrana pupillaris having thus broken in the centre, and retiring to the edge of the pupil, the two laminæ come once more in contact, and are closely united to each other at the extreme margin of this opening. Thus, instead of two closed serous cavities, we have both the anterior and the posterior chamber united, and lined by a continuous tissue, which secretes the fluid, and is known by the name of the aqueous membrane, heretofore limited to the posterior surface of the cornea.

It would carry us into too lengthy a discussion, were we to name the various hypotheses which have been advanced by different authors on the subject of the membrana pupillaris. It is sufficient for me to state, that I agree in the existence of the membrana capsulo-pupillaris, in so far as, that it lines the posterior surface of the iris, and is reflected off the points of the ciliary processes upon the anterior capsule of the lens. Still I cannot agree with Henle in his description of its origin from the anterior surface of the iris. On the contrary, I believe that it is adherent to the uvea, in like manner as the anterior layer is attached to the colored aspect of the iris, with this exception owing to the different nature of the surface; viz. that the black pigment, which is deposited upon the uvea, is placed between the iris and the membrana capsulo-pupillaris, as the same secretion is situated, with regard to the choroid, external to the reflected portion of Jacob's membrane.

Up to the fifth month of the fœtal life, the pupillary membrane exhibits no trace of vessels, it is soft and almost gelatinous: again at the end of the eighth and the beginning of the ninth month, it begins to disappear, and finally is altogether wanting at the term. Some rare instances are mentioned by Lawrence, Wardrop, Jacob and others, where its presence was observed even after the birth of the child.

Note to page 79.

Subsequently to the sheet containing the description of the retina being printed off, I had an opportunity of dissecting a human eye within a very few hours after death; in this instance, no appreciable escape of the fluids had taken place, the cornea was bright, and the globe firm: the examination was therefore carried on under the most favourable circumstances.

The consequence of this investigation has been somewhat to shake my belief in the existence of a fold in all the proportions stated at pages 76 and 77, except as a post mortem appearance. Should future enquiry prove the non-existence of such an arrangement of parts, I shall feel exceedingly happy in thus having had an opportunity of myself correcting the error into which I had fallen. The appearances presented in the case to which I allude, were as follow :—

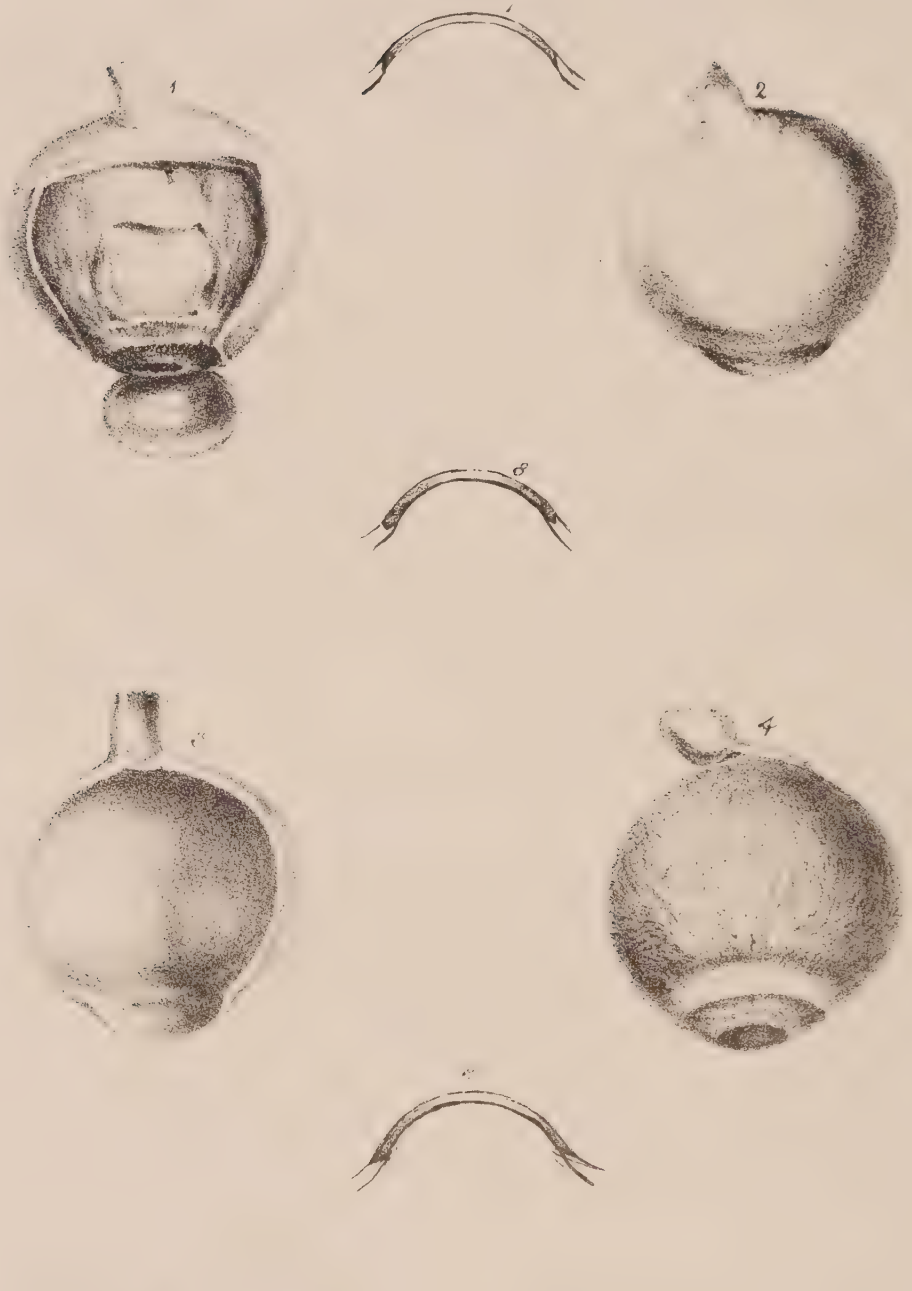
On making a transverse section through the eye, about one-fourth of an inch behind the cornea, and immersing the posterior portion in water, I observed the retina without fold or plica throughout. At the usual place of the spot of Soemmering, I found a minute cuplike depression with an elevated yellow colored lip around it. Instead of a duplicature of the retina, it appeared as if this membrane was indeed thicker at the immediate circumference of the central hollow, but still there was *neither fold, nor real foramen.* As soon, however, as the vitreous fluid partially escaped, the circular edges of the depression became elongated, elevated, and finally came in contact, presenting precisely the same fold which I had so often before remarked. This preparation, which I possess, shews at this time exactly the same appearance as is exhibited in Plate III, fig. 3. The original from which that drawing was made, is also in existence.

It is a curious fact, that this fold is always in one and the same place, directed constantly in a horizontal line from the entry of the optic nerve outwards: it is seen in all cases where the foramen of Soemmering exists; in the fœtus, the adult man, in certain monkeys, and in some lizards: in the chamælion there are two folds, placed on each side of the central depression.

As in this one instance I actually witnessed *the formation of the fold,* I suspect the whole to be the result of some post mortem change; and am therefore compelled to confess, the true nature of this very interesting portion of the anatomy of the retina is still a desideratum in our science.

March 1, 1834.

Plate 1st



rawn by J. Dalrymple

Drawn on Stone by W. H. Kearney

EXPLANATION OF PLATES.

PLATE I.

Fig. 1.

Represents the various tissues of the human eye, as exhibited by a section continued through the sclerotic and choroid coats, down to the retina. The cornea is separated from its junction with the sclerotic, and hangs down, shewing its concave aspect: the iris is partially seen, with its pupillary aperture in the centre. Above, the white line attached to the choroid represents the ciliary circle; and in the centre of the figure is the retina, somewhat loose, owing to the transudation of the fluid of the vitreous body.

Fig. 2.

Is simply the external case of the eye; the sclerotic coat, with the optic nerve entering above, and the cornea partially seen below.

Fig. 3.

A section of the sclerotic and corneal coats, shewing the general figure of a vertical and lateral section of the eyeball; the sheath of the optic nerve above is also divided, exhibiting the cul de sac formed by the lamina cribrosa.

Fig. 4.

Represents the choroid coat, ciliary circle, and iris: the tortuous lines on the exterior faintly exhibit the disposition of the vasa vorticosa. The preparation is suspended by the optic nerve.

Fig. 5.

A vertical section of the eyeball, shewing the concave aspect of

the choroid coat with the ciliary body, processes, and iris: the optic nerve, sclerotic, and cornea, are also added.

Fig. 6.

A similar section, with the addition of the retina. To the left of the entry of the optic nerve, is seen the fold and central depression mentioned in the description of the retina; and below, the anterior border of the retina, with its undulating edge.

Fig. 7.

The ordinary form of junction between the cornea and sclerotic, where the latter tunic overlaps the extreme edge of the cornea.

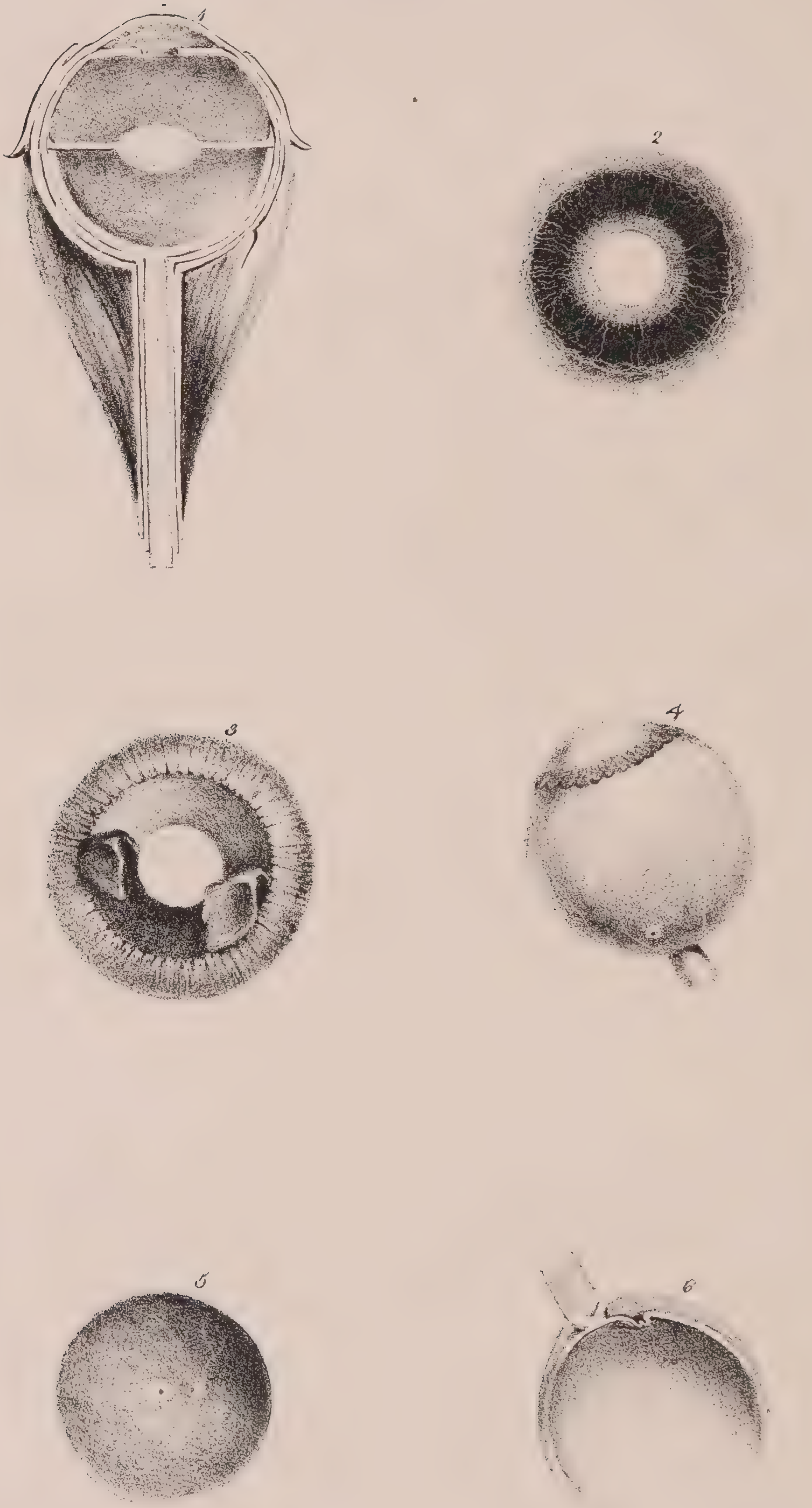
Fig. 8.

That form of junction where the cornea is received into a groove split in the thickness of the sclerotic.

Fig. 9.

The more rare mode of union, where the cornea overlaps the sclerotic coat.

Plate 2nd.



Drawn by I. Dalrymple. *Drawn on Stone by W. H. Kearney.*

PLATE II

Fig. 1.

This drawing is copied from a plate engraved in Vesalius' folio edition of his anatomical works, published at Leyden, in 1725. It is introduced here to shew the extraordinary error in the relative situation of the lens, and disproportionate size of the posterior chamber, entertained by that illustrious anatomist. The central transverse line represents the ciliary processes. It will also be observed, by following the lines marked in the sheath of the optic nerve, that Vesalius believed in the continuation of the cerebral membranes into the choroid and sclerotic tunics.

Fig. 2.

Exhibits, faintly indeed, the vascular arrangement of the iris, the outer or greater, the lesser vascular circles, and the radiating vessels intermediate between them.

Fig. 3.

Represents an enlarged view of the posterior surface of the iris, and ciliary processes. The superior portion of the uvea has been stripped of its pigment and serous covering, which is exhibited hanging down on each side.

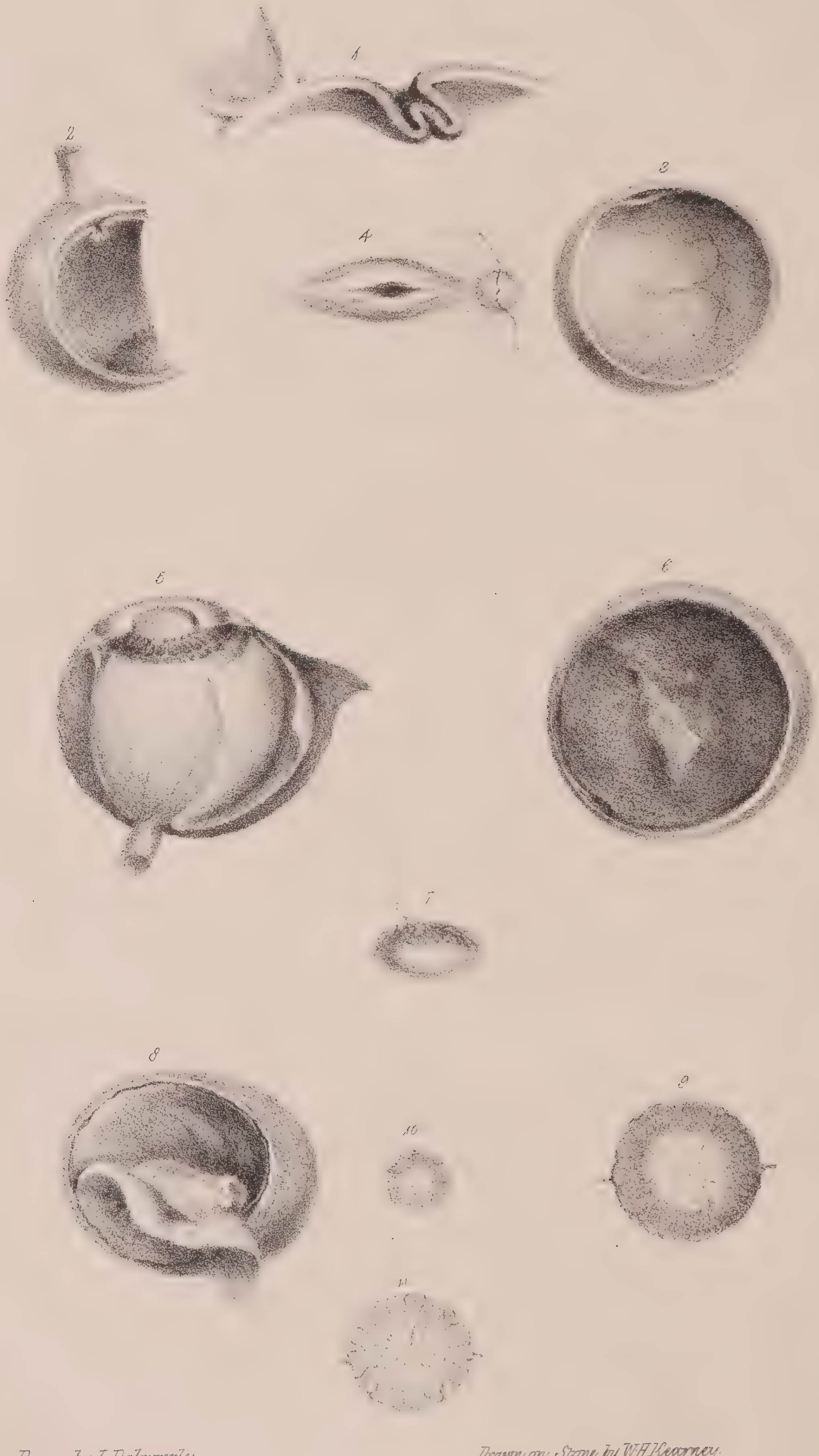
Figs. 4 and 5.

Are copied from the work of Soemmering, to shew his representation of the "foramen and limbum luteum."

Fig. 6.

A section of the optic nerve and retina, to shew the disposition of the central fold and depression.

Plate 3rd



Drawn by I. Dalrymple. Drawn on Stone by W.H. Kearney.

PLATE III.

Fig. 1.

Represents a section of the optic nerve and retina carried through the centre of the fold. By tracing the line of the retina, in this enlarged view from the optic nerve, we see how the fold is composed of the reduplication of the membrane with the central depression, which has given rise to the supposition of an actual foramen at this spot.

Fig. 2.

A section of the eye, of the natural size, exhibiting a similar disposition of the retina.

Fig. 3.

A transverse section of the eye, to shew a front view of the retina, its fold, and central depression. The entry of the optic nerve is seen, to the right of the fold with the two chief branches of the arteria centralis retinæ.

Fig. 4.

An enlarged front view of the fold, shewing the elliptical form of the central depression.

Figs. 1. *and* 4. are simply diagrams.

Fig. 5.

In this drawing are represented the choroid and iris, the optic nerve and retina, with the canal of Petit and crystalline lens in front. The two portions of Jacob's membrane are seen to the right of the plate ; one portion in contact with the retina, and the other reflected on the choroid membrane, which is cut open and thrown back. Near the optic nerve the two portions are seen connected, but anteriorly they have been split open, in order that they might be separated and reflected. On the left side, the two portions of Jacob's membrane are seen in situ. It is but right to say, that this drawing is solely a diagram to illustrate the subject treated of at page 99, and not copied from any actual preparation.

Fig. 6.

The choroidal reflection of Jacob's membrane detached from the tapetum, and hanging down in a shren. This is taken from a preparation of the eye of a sheep.

Fig. 7.

The arteries of the posterior capsule of the lens, derived from the branch of the arteria centralis retinæ, which perforates the vitreous body.

Fig. 8.

In this preparation, taken from the eye of a fish, the lowermost reflected portion represents the retina; the portion of membrane immediately above and also hanging down, is the Jacob's membrane properly so called; while the choroidal reflection is in situ, adherent to the choroid.

Fig. 9.

An enlarged view of the vessels of the membrana pupillaris.

Fig. 10.

The same preparation, of the natural size.

Fig. 11.

Another magnified view of the membrana pupilaris, and its arteries.

Plate 4th

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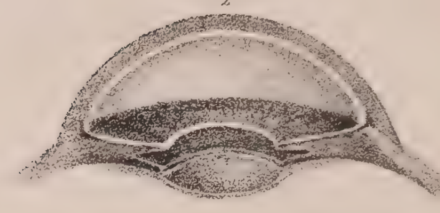

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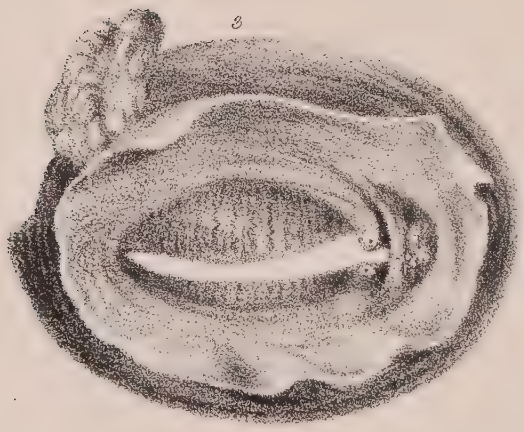

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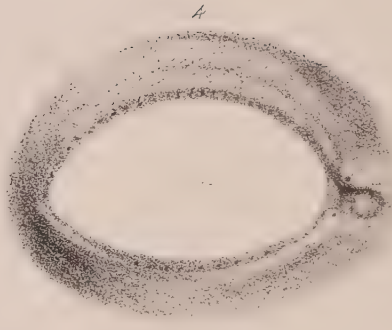

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Drawn by J. Dalrymple.

Drawn on Stone by W. H. Kearney

PLATE IV.

Fig. 1.

Is a diagram representing the two chambers of the eye, complete at this the fœtal period of life, from the septum formed by the membrana pupillaris. By tracing the white line from the posterior aspect of the cornea, the membrane will be seen to form a closed sac anteriorly, by being reflected upon the surface of the iris, and filling up the pupillary aperture. A similar membrane may be traced from the posterior surface of the iris, on to the anterior capsule of the lens, also forming a closed and serous sac.

Fig. 2.

Shews how, after the destruction of the membrana pupillaris, the anterior and posterior chambers are lined by one and the same membrane, now called the aqueous.

Fig. 3.

Exhibits a posterior view of the eyelids. The extreme circumference of the drawing shews some of the fibres of the orbicularis palpebrarum muscle. Above and to the right is seen the lachrymal gland. The two ovoid bodies, surrounding the central fissure, are the tarsal cartilages, with their vertical ranges of Meibomian glands, and covered by conjunctival membrane. The two small apertures to the left of the tarsi are the puncta lachrymalia ; and to the extreme left the membrana semilunaris and caruncle. The rest of the surface represents the palpebral conjunctiva loose and detached in part.

Fig. 4.

An anterior view of the eyelids, principally to shew to the left the lacus lachrymarum, caruncle, and puncta lachrymalia. The extreme margin of the palpebral fissure is marked by the openings of the Meibomian glands.

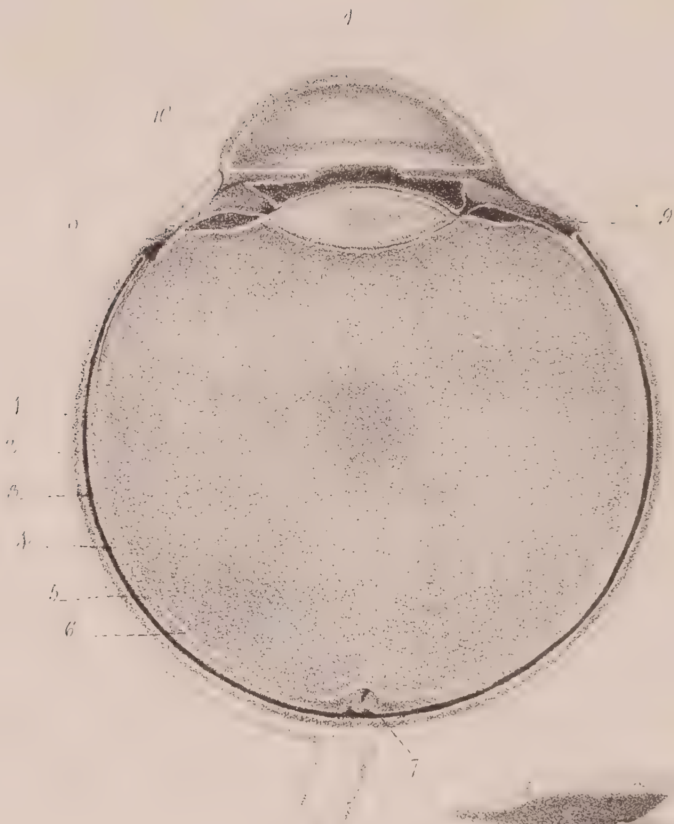
Fig. 5.

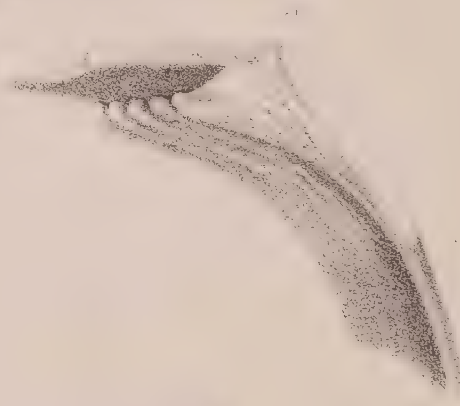
Is a representation of the ciliary body and processes surrounding but not attached to the crystalline lens: the scalloped circumference of the ciliary body marks the point denominated ora serrata, at which place the anterior border of the retina has its fixed attachment.

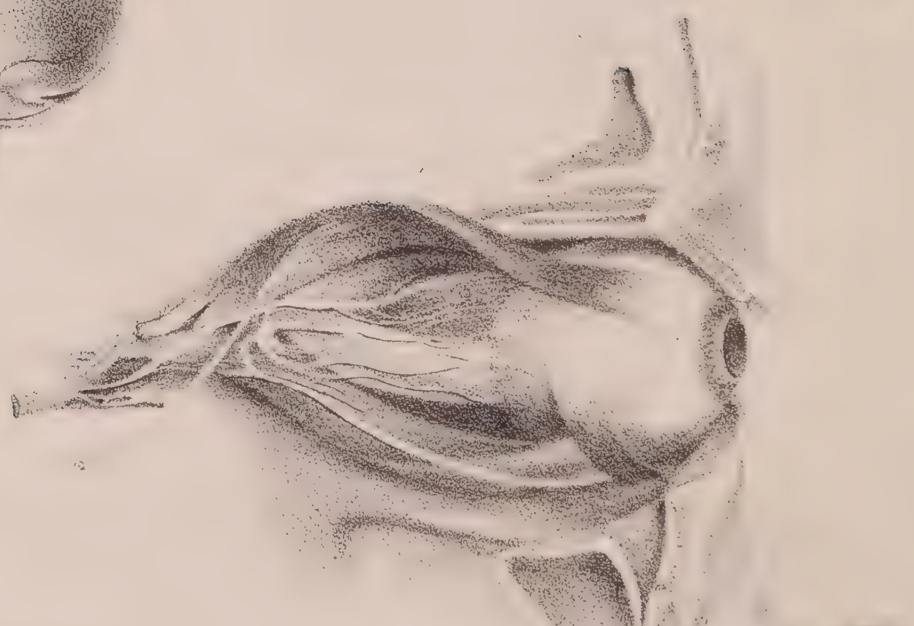
Fig. 6.

Represents the lachrymal canals, and lachrymal sac. It should be observed, that in this drawing the direction of the canals is too oblique.

Plate 5th.







Drawn by J. Dalrymple

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PLATE V.

Fig. 1.

This is a diagram representing a section of the human eye, drawn directly through the axis of vision, dividing the fold of the retina transversely.

1. Sclerotic coat.
2. Choroid.
3. Choroid reflection of Jacob's membrane.
4. Jacob's membrane proper. Owing to an error in the marking, No. 4 is drawn to the black interval between the layers of Jacob's membrane, instead of beyond this point on to the next white line.
5. Retina.
6. Hyaloid membrane of the vitreous body.
7. The central fold of the retina.
8. Represents the theory of the splitting of the hyaloid membrane, in order to form the canal of Petit.
9. Shews the zonula Zinnii, or proper membrane forming the anterior layer of the canal of Petit.
10. The aqueous membrane lining the posterior surface of the cornea, reflected upon the anterior surface of the iris, uvea, and over the anterior surface of the crystalline capsule; thus lining both chambers of the eye.

Fig. 2.

A vertical section of the eye through the central fold of the retina, to shew that it is sometimes formed by a single inversion of this membrane. From a preparation.

Fig. 3.

An enlarged section of the ciliary body and processes; the horizontal plane anteriorly, is portion of the iris; behind which we have the ranges of a few ciliary processes; to the left and externally is represented a section of the ciliary circle, to which the iris, choroid, and ciliary body are attached.

Fig. 4.

Is introduced chiefly to shew the arrangement of the ciliary nerves arising from the lenticular ganglion. The communication of that ganglion may be observed, below, with the branch of the third pair of nerves supplying the inferior oblique muscle; and above, with the nasal branch of the first division of the fifth nerve. The most elevated muscle of all, is the abductor oculi, raised in order to expose the ciliary nerves: it is seen supplied by its own peculiar nerve, the sixth.